JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] MARCH, 1867. [No. 3.

EDITORIAL.

THE interest of the manufacturing part of our community is at this time strongly excited by the steps which are being taken, in reference to steam-boiler inspection, by our local government. Nor is this interest, indeed, confined to a single class, since all who inhabit our city, must feel that the question involved, may at any moment become a personal and vital one to themselves, should unsafe boilers be allowed to run unchallenged until their unsound condition is revealed by some fatal catastrophe.

The committee who have it in charge to frame an ordinance which shall regulate the entire department of inspection and its operations, have called upon mechanical engineers and men of science, to aid them with their advice, and have by this time accumulated no small mass of wisdom and unwisdom, from various quarters.

The electrical theory has been broached and advocated, and a lightning-rod prescribed as a panacea. The theory of explosive gases has found an advocate and expounder, and the committee have been taught how to apply an antidote. All forms of indicators and tell-tales, have been commended by some and denounced by others;

hydraulic tests have shared the same fate, and on the whole, the most prominent idea in the minds of the Law Committee by this time, we suspect, must be, "who shall decide where doctors disagree?"

Under these conditions, we think that all will approve the course of the Franklin Institute, in arranging to hold special meetings for the purpose of discussing the proposed city ordinance, and then; when the best wisdom of its eminent and respected engineers shall have been by this means combined, digested and consolidated, to submit the same, with all the weight which such a combination must possess, to the consideration, of the Law Committee and of Councils.

Such services as those thus proposed, come peculiarly well from the Institute, for it was this body which in 1835–36 furnished to the Senate of the United States the draft of a bill which was duly enacted, and became the law governing the inspection of the boilers and engines of vessels propelled by steam.

The investigations which were made at that time by the Institute, and which were embodied in the Reports on Steam-boiler Explosions and on the Strength of the Material for Steam-boilers, (published in the volumes of this *Journal* for the years 1836 and 1837,) are widely known, and may be studied with advantage at the present time.

A committee of the Institute is moreover, now engaged, in concert with the officers appointed by the government, and a committee of the American Academy, in the prosecution of elaborate and important experiments on steam-expansion.

In connection with the same subject, we would call attention to the article on Overheated Steam-boilers, published in our issue of last month, and to the following quotation from an abstract of the report presented by the Chief Engineer of the Manchester Boiler Association, at a late meeting, which we find in the *London Mechanics' Magazine* for January 4th, just received. This is merely one, among a thousand daily recurring evidences of the necessity which exists for thorough inspection of steam-boilers, and we quote it, not because of its special individual importance, but because it shows how, at this time, explosions are actually being prevented by proper care.

"The case of fracture above alluded to is, perhaps, one more pregnant with danger than any before met with in the inspections of this association. It was found in one of three boilers, all of which were about seven feet six inches in diameter, connected together, and worked at a pressure of nearly sixty pounds on the square inch. The defect consisted of a crack, which ran from rivet-hole to rivet-

hole of the inner overlap of the plate, at a longitudinal seam of rivets near to the top of the boiler, the depth of the crack being half the thickness of the plate, while it extended to within a few inches of its entire width. Had it developed, as many cracks do, so as to lead to the rupture of the plate, the most serious consequences must have resulted. Not only would the shell of the boiler in question have been torn to pieces, but the adjoining boilers thrown from their seat, and possibly exploded from the shock, as has been found to be the case under similar circumstances. The boiler was but about three years old, so that it shows that 'entire' examinations are important even for new boilers."

In connection with the experiments and reports of the Franklin Institute noticed above, we cannot forget the great services rendered in the development of both, by Prof. Alexander Dallas Bache, whose loss the Institute and his country at large, have now reason to deplore. As will be seen from the Report of Proceedings on page 209, the decease of this eminent man was announced at the last meeting of the Institute, and appropriate resolutions were at that time duly proposed and adopted. All who on that occasion spoke from personal recollection of Prof. Bache, united in their praise of his generous appreciation of worth and ability, his indefatigable energy in the prosecution of research, his remarkable powers of organization and judicious selection of agents, and his genial, sympathetic and amiable character in all social and professional relations.

PRACTICAL PHOTO-LITHOGRAPHY.

Our readers doubtless remember the very interesting paper read before the Franklin Institute by Mr. J. W. Osborne, on the subject of Photo-Lithography, and his peculiar process for reproducing existing originals. We have recently seen some very fine specimens made by Mr. Osborne, in this country, and we believe he has now nearly completed his arrangements for conducting the process on a large scale, a company having been formed in New York for that purpose.

In this process the original drawing, engraving, pen-sketch or the like, is copied by the camera, and reduced or enlarged as may be required. From the negative so made, he prepares a peculiar print

upon paper, capable of being transferred to the lithographic stone. The integrity of the original is thus insured to the copy. Engineers will find this method of illustrating their works of great value, as fac-similes of most valuable drawings can be made with absolute correctness, and with no injury to the original. We may be able at no very distant day to show in these pages, specimens of Mr. Osborne's skill; for we shall certainly avail ourselves of the advantages of his process, at the earliest opportunity. . . .

UNION PACIFIC RAILROAD.

We have seen with pleasure a series of stereoscopic views made by Mr. John Carbutt, of 131 Lake Street, Chicago, Ill., illustrating the excursion to the 100th Meridian, October, 1866. Apart from being remarkably well executed pictures, they are of especial interest as a record of the progres of this great engineering work. Following the series, we can land with the excursionists at Omaha, and with them on their western journey visit the indian camps, and see the Pawnee indians, with a back-ground of palace cars. All the shops belonging to the road can be seen, and the numbers 222 and 223 show Burnetizing works at Omaha. After seeing the group standing at the 100th meridian, we can next, in 209, see the workmen laying the rails, (two miles a day;) and finally, in 208, one looks westward over a level country. Standing beyond the last rail we can see the sleepers in place, off, far off into the distance, and we can feel that it is "thus westward the monarch capital makes its way." . . .

THE CHICAGO LAKE TUNNEL.

We have likewise received from Mr. F. Carbutt, of Chicago, two stereoscopic pictures of the famous tunnel. One is taken in the interior at the shore-end, and shows the vault for some distance with a car (such as was used for removal of earth, and carriage of building material) standing on the tram-way. Magnesium light has evidently been employed to secure this picture. The other view shows the "crib" used for the lake-end of the tunnel, as it appeared before launching. Numerous figures, clustered like bees upon the structure, give a vivid idea of its enormous size. We see also that this "crib" is square, and not eight-sided, as stated some time since by one of our contemporaries.

HOW TO SELECT INDIAN INK.

INDIAN ink, or Chinese ink, as it is sometimes called, when wanted for the purpose of mechanical drawings, is best tested in the following manner:

Rub in a porcelain paint-dish, as usual, to the required consistency. Then, with it, rule a number of lines on a piece of drawing-paper, making the lines of various thicknesses, corresponding with the fine and shade lines of a drawing. When the lines have dried, brush over them with water freely. Good ink will stand the washing and the lines will keep sharp and clear; poor ink will run or spread sideways as soon as the paper is wetted. The best ink comes from Japan. It is rather hard to rub, but to overcome this difficulty use a piece of slate, say one and a half inch wide and four inches long, resting one end in the paint-dish in which some water has been poured about four or five drops. Then rubbing the ink on the slate, close to the water, and washing it down into the water, it will soon obtain the required blackness.

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JAM-NUTS AND THEIR OFFICE.

THE remarks of council and questions put to witnesses at the late trial, arising from the loosening of a nut and consequent fall of a heavy piece of machinery, drew our attention to the general want of correct ideas on the subject specified in the above title, and we believe a few words of explanation will not be misplaced.

The office of a jam-nut is, first, to secure in place and take up the play in adjusting screws which require to be loosely fitted so as to turn readily, and when set require fastening. Second, to keep in place a nut on a screw, having no other bearing to secure its position, as in the stud or standing bolts of the stuffing-boxes for valve-rod, piston-rod, &c. But where a nut is already screwed down to a bearing, and jammed against a nut-bearing, the addition of a jam-nut is entirely useless, and serves only to transfer the binding strain from the first nut to the second one, and if there is any play in the threads of the screw or nut, the first one will be relieved of its pressure and will act as a washer only between the last nut and the bearing. In the case alluded to,

an eye-bolt at the top of the cage of a hoisting machine, to which eye-bolt the hoisting machine was attached, was secured by a nut which drew it down hard on to a shoulder, but after many years' use the nut came off and the cage fell down the hatchway. The builders of the machinery state that they had screwed up the nut and then riveted the bolt over the nut. The nut, however, may have been removed at some time to do some repairs and been replaced without that precaution. And various theories were advanced to account for its working off—all mere surmises, of course. If the twisting and untwisting of the chain gradually unscrewed the nut, a better plan than resorting to jam-nut, under the already firmly secured nut, would have been to have made a part of the nut, where it passed through the metal square, and fitted it into a square hole. The chain could not in that case have turned the eye-bolt. . . .

Engineering Items.

Compressed wood-packing for surface condensers.—On the occasion of a late visit to the Novelty Works in New York, we saw, among other ingenious and interesting appliances, the articles above-mentioned, in course of manufacture. In surface-condensers, where the condensing-water passes through small tubes, it is essential that these should be so held in the tube-plate, as to allow lateral motion without loss of tightness in the joint. To gain this end, a machine has been made by which wood of the character of seasoned, straight-grained white pine, being shaped into short tubes, these may be compressed to two-thirds their original thickness.

This is accomplished by threading the tubes on a conical spindle, which carries them into a conical die, by which means the walls of the tube are compressed as required. These compressed cylinders are then placed on the ends of the tubes in the holes of the tube-plate, which are sufficiently large to receive them readily. On the application of moisture, however, the wood-fibre swells so as to make a perfectly tight joint, which will, however, allow the necessary lateral movement to take place.

A Lenoir gas engine is now in operation in this city, at the establishment of H. A. Fisher, 415 Arch Street, where it has been put up by Messrs. Canby & Brother, who are the agents for this apparatus in Philadelphia.

The Hicks engine.—We have received from several sources good accounts as to the performance of this motor, and propose at an early date to give our readers a full illustrated description of its details in its present improved and efficient form. At present we merely premise that in this form of engine, all valve-gearing, eccentrics, links for reversing, boxes and many other parts are dispensed with, to the great economy of first cost, maintenance and space occupied. Two cylinders and pistons, placed side by side, are so arranged that each acts as a valve for its companion. The whole plan is entirely original, very ingenious, and seems to prove practically efficient. One of these engines has for some time been employed in the establishment of Mr. Joseph Harrison.

A road locomotive built by M. Schinids is in successful operation in the vicinity of Zurich, as is stated in a Lausanne paper.

Wire making, by a continuous process of rolling, is now conducted on a large scale by Messrs. Johnson & Nephew at Manchester. The iron, in blooms of one hundred and two pounds, is heated in a Siemen's gas furnace, from which it passes directly through a series of rollers which are geared so as to give an increasing velocity proportional to the elongation of the bar, and by this means one end is being wound on a reel, finished, while the other is still in the furnace.

Steel-headed rail.—A compound steel and iron rail has been shown to us which was manufactured at the Wyandotte Rolling Mills (from Bessemer steel, and iron, manufactured at the same place,) which is produced by a peculiar mode of piling, devised by Mr. S. L. Potter, superintendent of the above works. The plan employed consists in so placing in the furnace a rail pile, containing a bar of Bessemer steel five by four inches in section, that the steel receives heat through the iron, and thus the true welding heat of both iron and steel is reached at the same time, by which means a very perfect weld is secured. These rails cost but forty per cent. more than the ordinary iron ones, and it is said will outwear those entirely of steel, especially when exposed to severe cold, while the cost of these last is double that of the usual iron rail. We subjoin a record of some tests lately applied to these in comparison with a Dortized rail.

Record of the comparative test of a Dortized rail with a steel-headed rail made at the Wyandotte Rolling Mill, Michigan, (S. L. Potter's patent.) Test made by Wm. M. Lyon, Esq., of the Sligo Iron Works, Pittsburgh.

A weight of sixteen hundred pounds was allowed to fall four feet upon a piece of Dortized rail five feet long; it broke at the first blow.

A piece of the steel-headed rail made at Wyandotte, was then put under the drop, and subjected to four blows as follows: For the first blow, the weight was raised five feet; for the second, ten feet. The rail was then turned over, and received the third blow with a fall of fifteen feet, and the fourth blow, with a fall of twenty feet, bent the rail almost double. The rail was then taken to the steam hammer whose weight was eight thousand eight hundred pounds, and received ten or twelve blows. When the bar was nearly straightened out, it broke, but the iron and steel remained perfectly welded together. One of these pieces was then subjected to one hundred blows from the eight thousand eight hundred pound hammer on the head of the rail, as follows: Fifty blows at two feet fall, and fifty at three feet fall. This crushed the rail without breaking the weld of the iron and steel. The above tests were made March 1st.

The boring of large cylinders is conducted at the Novelty Works in a very simple and ingenious manner. All framing (which in this case would be very bulky, costly and cumbrous) is dispensed with, and the cylinder to be bored, is pressed into service, as frame and support for the tool which is to finish it. The cylinder, in fact, being firmly secured in an upright position, on a bed-plate which has a central bearing for the boring shaft, this last is lowered into it, and secured by proper adjustments to the upper edge, whereupon the *boring machine* is complete.

Improvement in pumps.—At the last meeting of the Institute, there was exhibited an improved form of pump, invented by Mr. Robert Cornelius, and very efficient in dealing with mingled compressible and incompressible fluids, such as the water and gas found in oil wells. The prominent feature in this plan is, that when the piston reaches the upper end of its stroke, it opens or exposes a communication between the spaces above and below it. If, therefore, gas has been drawn in from below, and there is water in the pipe above, the two exchange places by reason of their different densities, and the gas is driven out instead of cushioning under the piston and rendering its motion ineffective, as is otherwise the case. These pumps have been of great service in the oil wells, but their range of application is by no means restricted to this field.

The fouling of mercury gauges may be prevented by introducing a few drops of glycerine in the tube, on top of the mercury. The glycerine by its superior adhesion, lubricates the glass and keeps the mercury from contact with it.

Civil and Mechanical Engineering.

(Continued from page 107.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

TO THE public, or rather to what we are fain to consider a small and ungracious part of it, we would simply say, do not do yourselves injustice by failing to open your eyes to the progress around you, to the advances, capabilities and true merits of the profession. In whatever department or function that pertains to it, judge of it by the rule that applies to all professions and vocations, without antiquated prejudices; investigate its failures and shortcomings, if such run more in your mind than its successes, be well assured of their causes, and determine whether they are inherent or hereditary, or accidental and exceptional. If you have need of a physician, you look for one who has had opportunities of perfecting himself in the healing art, and has availed himself of them in theory and practice;—so with the engineer; inquire into the groundwork upon which he builds, see whether he has employed the means that have given success to others; make yourselves somewhat acquainted with his profession, (you have not neglected this in the case of the physician;) what are its legitimate duties and scope; is it probable the engineer will succeed better in doing what his education and practice have fitted him to do than another person who has not had such education and practice; has he succeeded or failed in what he has attempted to do, on whatever scale it may be? &c. By this sensible mode of reasoning, which you are doubtless accustomed to in ordinary affairs, you will be able to arrive at a safe and practical conclusion.

The ancient Romans were the most notable road-makers of whom we have any account. They made their roads on a liberal scale, both as to mode and extent, and with unstinted labor and cost, and, considering the main object they seem to have had in view—indestructibility rather than convenience,—they were made with great skill. Their plan was copied from the most indestructible form of nature—the solid rock, and with their imperial ideas and imperial power, it was carried out by following the closest imitation practicable. Rocks

were detached from the quarry in masses that could be transported, hewn into proper shape and replaced together closely joined, to form the superstructure of the road, a foundation having been previously prepared, with great pains, to receive and support the material. The rigid and unyielding surface was made sufficiently smooth for use, and the Roman ideal was attained of a work that was imperishable.

Samples that are still extant show how thorough was the workmanship, and how well the builders understood their art; the broad blocks of stone show evidence of long service in the groove-marks of carriage wheels that passed over them two thousand years ago, but in other respects no change has apparently taken place since the work was constructed. One peculiarity of the Roman roads, besides their solidity, was their general straightness, no ordinary obstacle being permitted to turn them from their direction and cause sinuosities. Ascents, descents and declivities, far more objectionable, were secondary to this principle. "This has been attributed to an imperfect knowledge of mechanics, for the Romans do not appear to have been acquainted with the movable joint in wheel carriages. The carriage body rested solidly upon the axles, which, in four-wheeled vehicles, were rigidly parallel with each other. Being unable readily to turn a bend in the road, it has been concluded that for this reason all their great highways were constructed in as straight lines as possible."*

No improvement appears to have been made upon the Roman plan until within the last one or two hundred years; the art seems to have retrograded even, rather than to have stood still, for a long time after the Roman era. The progress was extremely slow when it commenced, the principal advances being found almost within the present century. It has been said by a modern writer, that the roads of a country or a community are a correct index of the degree of civilization prevailing with the people, and this idea is well illustrated in recurring to the long interval in the past during which no progress was made in the art of road-making.

In England, as late as the reign of Queen Elizabeth, the state of the roads was such that traveling was done throughout the kingdom principally on horseback, by horse-litters and on foot. Coaches are said to have been first introduced into England during that reign. The mode of making roads, up to that time, was but a poor imitation of the old Roman mode. The remains of the old Roman colonial works still existed in many places, and were probably the best portions

* Smiles—*Lives of the Engineers.*

of the roads in use. It had become so difficult to maintain the more modern roads that they were, from time to time, abandoned for new tracks that were opened through fields and across lots, (as is the case sometimes in this country, with roads that are temporarily obstructed by snow in winter.) Roads that had long been in use were, in some places, so worn down into the soil, by neglect and the action of rains, as to form trenches or chasms thirty to forty feet deep, which gave rise to local names, as Holloway, and the like. The streets of London were no better than the roads of the country, a filthy stream being permitted to flow through a roughly paved gutter in the middle of the street, improved carriage ways and flagged sidewalks, as now in use, being then unknown. The transportation of the country was done by pack-horses, with panniers, going in droves, in double or single file, clambering over all sorts of ground that would be considered, at this day, impassable. Notwithstanding these difficulties, the introduction of an improved class of roads and stage-coaches met with much popular opposition. Long after the introduction of stage-coaches the roads continued to be so bad as to nearly prohibit their use. A writer of the time, who had made a journey to London by coach, says: "This traval hath soe indisposed me yt I am resolved never to ride up againe in ye coatch." Coach traveling was not only a great hardship, but was extremely dangerous, from the numbers of serious accidents and misadventures that were reported to have occurred. When these things are remembered, it is not to be wondered at that Doctor Johnson was wont to extol the pleasures of a drive, with a spirited horse and an agreeable companion over a fine road, as among the greatest enjoyments of life, when such a —— exhilirating kind of exercise became safe and practicable. The Doctor had been obliged to make his wedding tour on horseback.

It may be noted, that among the objections that were urged by the opponents of stage-coaches and superior roads, was that which arose from a fear of apoplexy, caused by the "incredible speed" of six or eight miles an hour; a number of cases were referred to as having been produced by this "too great rapidity of motion." The journey from Glasgow to London was made, in 1774, by a "flying coach," in the space of two weeks.

Arthur Young says, at a later date, of a road that he had traveled, "I know not, in the whole range of language, terms sufficiently expressive to describe this infernal road. Let me most seriously caution all travelers who may accidentally propose to travel this terrible

country, to avoid it as they would the devil; for a thousand to one they break their necks or their limbs by overthrows or breakings-down. They will here meet with ruts, which I actually measured, four feet deep, and floating with mud, only from a wet summer. What, therefore, must it be after a winter? The only mending it receives is tumbling in some loose stones, which serve no other purpose than jolting a carriage in the most intolerable manner."

Sidney Smith, at a considerably later date, says, characteristically, that "Before the age of stone-breaking, MacAdam, and of railways, it took him nine hours in traveling the forty miles between Taunton and Bath, during which he suffered between ten and twelve thousand severe contusions, whilst his clothes were rubbed to pieces by being jolted about in the stage-coach basket, which was without springs." "Whatever miseries I suffered," he adds, "there was no post to whisk my complaints, for a single penny, to the remotest corners of the empire; and yet, in spite of all these privations, I lived on quietly, and am now ashamed that I was not more discontented, and utterly surprised that all these changes and inventions did not occur two centuries ago."

These examples of the condition of the English roads are taken from the work before referred to, by an English writer. They will suffice to show the great need of a higher civilization—if roads are taken as the test—than existed in one of the most advanced states of Europe up to the beginning of the present century.

The same writer gives numerous instances of the state of society, that very much strengthen the idea of an intimate relationship between superior roads and superior intelligence and refinement.

It would be unjust to omit a reference to his subsequent interesting description of the progress and improvements that followed, after this period, in English road-making. The prejudices against the innovations of stage-coaches and other vehicles, and roads adapted to their use, gradually wore away, and with the growing desire and necessity for improvement, the work at length was taken hold of in earnest, and put in the hands of a class of men who were equal to the task demanded. The fullness of time had in fact arrived, when a new era was about to be inaugurated, which was not only to make advances upon the old Roman ideas of road-making, but was to renovate, in a more enlarged sense, the ways of the world; perfecting old arts and developing new ones; enlarging the scope of human thought and action, and expanding the field of human enterprise to an extent never

before dreamed of. The next seventy-five years was to represent, in progress, many preceding centuries. It was thought singular, as far back as 1768, that the engineer, Smeaton, should give his attention to the subject of road-making, as, from the low state of the art, it was considered a condescension, and derogatory to an engineer to devote his time to the business. But this prejudice was soon to pass away. The successors of Smeaton—Brindley, Rennie, Telford and others, most distinguished in the profession—entered upon the duties, in the employ of the government and of incorporated bodies, and brought their highest skill and qualifications into the service. Between 1784 and 1792, three hundred acts of Parliament were passed, authorizing the construction of roads and bridges, and within the space of a few years these engineers surveyed and executed a well-planned system of roads and bridges over several parts of the kingdom. John Rennie, a Scotch engineer, was among the most prominent in the construction of bridges. Among his works of this kind are the Waterloo, Southwark and New London bridges over the Thames, besides many others, in England and Scotland. The New London bridge was designed by him, but completed by his son, Sir John Rennie. For his success in the design and construction of Waterloo bridge in particular, the elder Rennie was offered the honor of knighthood, but declined it. He was the first to adopt the method of breaking up stones into small pieces, to form the surface of roads, which came into extensive use afterwards under the general name of MacAdam roads. He seems to have claimed no special merit for the invention, and the public were misled into awarding the credit to MacAdam, who did not make such roads until several years later. It may be remarked here, also, that Rennie was the inventor of hollow walls, as made use of in large structures of masonry to admit of greater breadth of foundation with less weight, which was subsequently appropriated by another person, (not an engineer,) and the invention patented by him.

In 1803, Telford—also a Scotch engineer—undertook, in the employ of the English government, the survey and construction of nine hundred and twenty miles of roads in Scotland, and in connection with this work, he built, it is said, no less than twelve hundred bridges, many of them large and costly, and they are still among the finest specimens of bridge architecture extant. He was employed at this about twenty years. So extensive and successful were Telford's works of this kind, that he was humorously designated by his friend—the poet Southey—as "Pontifex Maximus." He continued, later, the

construction of roads (upon a superior plan specially designed by himself, which will be described hereafter, and which has since appropriately gone by his name) in England and Wales, until the general progress and spirit of enterprise which had been engendered in the direction of common roads was abated by the construction of canals, and the incipient advances of railways. His greatest work, as an engineering achievement, is probably the suspension bridge over the Straits of Menai, although his roads, harbors and canals were of greater general utility.

England is indebted to no man more than to Thomas Telford for her material prosperity growing out of the multiplicity of public improvements that he executed. The list of the works that he planned and carried out, through a long and active life, would fill many pages. The engineering profession has had no more able exponent His example and works afford a highly profitable study to the young engineer. He was self-made, rising from humble origin, and encountering many obstacles in early life. It is proper to add, that he was honored and appreciated by his government and people, and finally found a resting place in Westminster Abbey.

Telford remarks upon the astonishing effects of the early improvement of the roads of the country upon the customs, manners and industry of the people. "By these improvements," he says, "the moral habits of the great masses of the working classes are changed." "I consider these improvements among the greatest blessings ever conferred on any country." "It has been the means of advancing the country at least a century."

Since his time it has not been held as derogatory to engineers to give their attention to road-making, nor has it been found that the art was unworthy of some of the best efforts and appliances of engineering skill. A great deal of time has accordingly been devoted of late years to the investigation of the subject, and numerous modes and expedients, together with a great variety of materials, have been resorted to for the purpose of improving or economizing the construction of roads, and much ingenuity and ability have been expended and treatises written upon them. It will not be practicable to cite here these examples. Such hints and ideas as have been culled from them and found available and advantageous, have been embodied in the roads of the Park.

There is no doubt that great improvements are still to be made in road-making—in the discovery, perhaps, of new materials, and in dif-

ferent modes of treatment—to produce more agreeable adaptations of the surface of roads, and possibly greater economy and facilities of construction, but in the various plans that have hitherto been brought into public notice there is nothing to indicate that such improvements are likely to occur immediately, or, at least, to be of such a nature as to supersede the prevailing practices. The safest course, is believed to be, to adhere to plain general principles of construction that have been well demonstrated, and to employ the usual materials (of the best available quality), such as seem to be naturally provided for the purpose, to perfect the mode of treatment and details in all practicable ways, *and to perform the work in a thorough manner.*

The Roman idea of an indestructible road is impracticable; a road that will endure even more than a very few years, it is inexpedient to attempt to make at the present day; for such a road, if it could meet the conditions of economy, would not be likely to meet the conditions —which are quite as absolute—of ease, convenience and safety. The best that can be done, in the way of endurance, is to prepare a foundation that will remain intact when the superficial material wears away, and that will permit the renewal of that material without disturbance or decay. The efforts that have been made to construct city pavements that would resist the destructive forces and ceaseless abrasion they are subjected to, and obviate the necessity for almost constant repairs, have generally failed. The Russ pavement, cast iron pavement, and other forms that have been tried in the city of New York, are instances of this kind. The Russ pavement, composed of large blocks of stone, is an imperfect repetition of the old Roman road. The present method of paving with small cubes of stone, (called the trap block pavement,) if done on a suitably prepared foundation, seems to be about as well adapted to all the conditions of the problem—as regards city streets and great thoroughfares—as can reasonably be expected for some time to come. It is not easy to see how this method could be improved (though it doubtless will be) if carried out thoroughly and faithfully. The materials are abundant, accessible and—as to the stone, from the Palisades—of the best quality, and inexhaustible. The foundation *can be, and should be,* prepared in the best manner, so as to give a firm and equable support to the stones, and obviate caving in and disruptions, and of a sufficiently permanent character to admit of the renewal of the stones without breaking it up. The size of the stones is about a practical medium, sufficiently large to prevent crushing, and small enough to be spanned by a horse's foot,

in such a way that one or more of the points of the shoe, when put down, will strike into, or very near, a surrounding crevice, to prevent slipping. The bottoms of the stones have breadth enough, when properly squared, to give them a good bearing on the foundation material, and the upper surface is as even and regular as is compatible with the mode of construction—not as smooth (or as dangerous) as the Russ pavement, nor as rough as the cobble-stone pavement. It is not adapted to pleasant or comfortable driving, and therefore not suitable for a park or private grounds. For these purposes, a less expensive form of road is preferable.

In closing this chapter, it will not be amiss to add a remark upon our common roads in the country. In reviewing the condition of the English roads, in the last century and the forepart of this, we cannot felicitate ourselves with the idea that the picture was painted in the olden time, and has no relevancy to us; it fits closely to a state of things that existed nearly cotemporaneously in this country, and which has, unfortunately, not wholly disappeared even at the present enlightened day. Without referring to examples of stage-coach traveling that would set many people's bones to aching, and recall experiences of suffering and privation, we may say that it is not necessary to go far, or to search very carefully, for cases of bad roads; we may not find them with "ruts" quite "four feet deep," but we will find that it is still a prevalent practice in making, as well as in repairing, roads, to "tumble in loose stones," and to cover them over, more or less, with most unsuitable materials. In repairing (so-called) country roads, in particular, it is a common and most reprehensible practice, after tumbling into the ruts loose stones, to run a plough through the side ditches and scrape together into the middle of the road the long collected compound of road detritus, mud and weeds, and other unwholesome matter, resulting in the forming of a compost bed that lasts but a brief time, and then disappears in clouds of dust, or in mud, leaving the projecting stones to "jolt a carriage in the most intolerable manner." With abundant materials that the country furnishes, in most cases, for making respectable, if not superior, roads, at but little if any greater cost, (at less cost, in the long run,) these slip-shod practices continue. How often do we see those "hollow ways" in country roads, consisting of deep and dangerous gullies, worn down by rains that are permitted to concentrate from adjoining grounds, until the well-worn bed presents the appearance of having been designed for an artificial water-channel to drain the surrounding country, rather than for a highway for public convenience.

There was some excuse, in the new condition of our country, some years back, for not taking the lead of other countries in the civilizing art of road-making, and allowances are still to be made, in the recently settled or sparsely settled portions of the country; but in the older portions, surrounding our principal cities and villages, and containing prosperous populations, there would seem to be no palliating circumstances for the common neglect of the public highways. We seldom see the individuals composing a community practicing, in their private affairs, the wasteful economy and unthriftiness that is shown in the treatment of their roads; and it is quite as rare to find a man who is not fully aware of the wisdom of a better policy, and who is not sufficiently intelligent to know how, in some measure, to apply it, but the system of making it everybody's business and nobody's business to attend to the work prevails, and the evil is not corrected.

(To be continued.)

(Continued from page 89.)

THE STEAM-BOILER.

By Joseph Harrison, Jr., Philadelphia.

In the finding of the Coroner's jury in a recent boiler explosion in the city of Philadelphia, by which five men lost their lives, we find the following:

"That those in charge of these boilers, exhibited culpable negligence in regard to the precautions universally considered as essential to the safe management of steam-generators, and were not sufficiently experienced to render their management of such apparatus safe. A similar want of knowledge, experience and care is only too common among those using steam-power."

"That the proprietor was guilty of neglect in failing to provide a competent engineer to take charge of the steam motors of the establishment."

"In connection with this occurrence, this jury reiterates what has been already most strongly expressed under like circumstances, that official inspection of all steam-boilers should be provided by our local government, and is as essential to the safety of life and limb among our citizens as any part of our police regulations. The storage of gunpowder in our city is prohibited by law, but any one may place a steam-power magazine, with match burning, at our side or under our feet, with perfect impunity. Such magazines undermine, in fact, our most

crowded streets, and, unless properly cared for, will one day reveal their existence in fearful disaster."

There is much for reflection in these extracts, and their teachings should not be passed unheeded. In the use of steam in stationary engines, of small size, in our large cities and towns, (and from these as much harm can arise as from larger ones,) it is almost the rule to employ men of no experience or skill, who are utterly incompetent to fill the most important post of firemen. The mere fact that they themselves are in the greatest danger, fails to make them more thoughtful, and they ignorantly and carelessly go on, from day to day, hanging on the very verge of disaster, which may, at any moment, be precipitated by their own negligence. Almost unaware of the tremendous power that is in their keeping, and failing to profit by the plainest evidences of danger, a long continued immunity, often leads them recklessly to think that no harm can arise, even when danger is most imminent. And in the matter of inspection of boilers of stationary steam-engines, insisted upon so strongly, something also may be said. It is no doubt true that the regular government inspection of steam-boat boilers has been productive of good, but, at the same time, too much reliance should not be placed upon even this safeguard. It is well known that a steam-boiler may pass inspection, and be, or appear to be, at the moment, all right, but it is equally well known that in a day, or even in an hour thereafter, it may, by bad usage or neglect, become entirely unsafe. A steam-boiler may pass the most critical examination, and may stand with impunity a severe hydraulic test when cold, but a much less pressure, superadded to the strains resulting from irregular expansion, when hot, might rend the same boiler into fragments. It is plain that the fracture of steam-generating apparatus, can and may occur, under any system of construction. No amount of official inspection or special care, can entirely prevent this, and it must be set down as an imperative law, if safety is to be secured, "*that all boilers should be so constructed that their explosions may not be dangerous.*"

Having said thus much upon the general question of steam-boilers, it now becomes my province to describe the

HARRISON STEAM-BOILER,

An invention of my own, now being largely made and rapidly introduced into practical use. I had long turned my attention to the subject of improving the steam-boiler, and believing that better guiding principles were needed, I at length fixed in my mind the following axioms:

1st. That a steam-generator, of whatever form or material, must, as a paramount condition, be absolutely secure from *destructive* explosions.

2d. That it must be constructed upon a system of uniform parts, simple in form, few in number, easily made, and easily put together or taken apart, and not of costly material.

3d. That its strength should, in no respect, be dependent upon any system of stays or braces, whereby the inefficiency or rupture of one of these braces or stays, could cause greatly increased strain upon the others, thus endangering the whole structure.

4th. That its parts should not be of great weight or size, thus permitting greater portability, and greater facility for getting it into or out of place.

5th. That it must have a principle of renewal, allowing the easy displacement and replacement or interchange of any one or more of its parts, without disturbing or impairing the material or workmanship, of the remaining portions of the structure.

6th. That a boiler, whether of large or small dimensions, should have uniformly such elements of strength as would render it always capable of safely sustaining many times greater pressure than need ever be demanded of it in practice, and that its safety should not be impaired by corrosion, or the many other harmful influences which so soon and so seriously affect the strength of ordinary boilers.

7th. That the parts should be so made and put together, that in case of rupture of any portion of the boiler, no general break up of the structure could occur, the release of the pressure by such rupture merely causing a discharge of the contents, without explosion or serious disturbance of any kind.

8th. That it should be constructed so as to permit the easy and certain removal of deposit of all kinds from every portion of its interior or exterior surface.

These axioms being carried out, all else being equal, it is believed that the result must be a better and safer steam-generator than any that has preceded it. It is not important here to enter into the detail of how the "Harrison Boiler" reached its present form. Suffice it to say, that when the form of a hollow sphere and curved neck was decided upon, as shown in the illustrations herein, it seemed that the true principle had been arrived at,—that nothing more could be desired in that direction. A boiler of about seventy-five horse-power, the first of the kind, was made of these simple elements, in the spring of 1859, and put in operation at the establishment of Messrs. Wm. Sellers &

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Co., Philadelphia. This boiler effectively and economically supplied steam for driving the extensive workshops of the above firm, for several months in the summer of the year above mentioned. Its trial settled the question previously in doubt even with myself, that a boiler, as hereafter to be described, could be made and used without its integrity being disturbed by irregularity of expansion and contraction, consequent upon the action of fire. In practice up to the present time it has been usual to cast the spheres eight inches in external diameter and three-eighths of an inch thick, placed in groups of two and four, making what may be called a brick and a half brick. These spheres are arranged in a straight line one inch apart between their external diameters, and are connected with each other by a curved neck about three and one-quarter inches in diameter inside at the smallest part. A series of half necks make an opening entirely through each of the spheres, at right angles to the necks previously described. These groups of spheres are called "units," and when jointed with a rebate joint, accurately made on the edge or least diameter of the half necks, fit closely together, making, when these edges are adjusted to each other, and drawn together, a perfectly steam and water-tight joint, without the intervention of cement or packing. Any number of these two and four sphere units, when placed together with break- joints, may be conveniently made into a parallelogram or other form that may be desired. The distance between the centres of the spheres in the direction of the jointed or half necks, when the units are laid together, is the same as the distance in the transverse direction, thus making a uniform section or slab of any given length or breadth. Wrought iron tie-bolts pass through each line of spheres in the direction of the half, or jointed necks, connecting at each end with caps that close up the external orifices of the section. One of the caps, called a blank cap, is made to receive a T-head at one end of each bolt; the other end of the bolt passing through the opposite cap, and ending outside with screw and nut. It will be readily seen that these tie-bolts, when properly tightened, will bind all the units in one section firmly together. A section or slab of six spheres wide, the upper rows twelve, and the four lower rows thirteen spheres long, will make a boiler of about six horse-power.

In setting a boiler ordinarily, for stationary purposes, one or more of the sections are placed on edge, at an angle of about forty degrees, side by side, usually one inch apart between the sections, the upper corner on the bottom line being supported on a cast iron rail or bearer, the lower portion resting on a chair, adapted to the purpose, placed

behind the bridge-wall. A common steam-pipe, taking steam from the upper caps, connects any number of sections together. A similar pipe, in like manner placed at the bottom corner of the section, makes a water connection between any number of sections. To avoid binding of the parts from irregular expansion or disturbance of any kind, the steam and water-pipes are made up of short pieces, joining with spherical joints, held together with tie-bolts, after the manner of the units. By this means a flexible, or articulated connection is made, that prevents all trouble in joining the sections together.

No attempt is made to provide steam room other than the capacity of the spheres in the upper angle of the sections above the water-line. The amount of steam space is a little less than one-third the contents of each section, the remaining portion of the section being filled with water. It is found in ordinary practice with the largest boilers that the steam space allowed as above, is quite sufficient. The heated products of combustion, rise from the grate, passing between the sections, and amongst the spheres, and over the bridge-wall, finding exit at length towards the chimney at the lowest and coldest part of the boiler. A cast iron guard is inserted between each slab, nearly horizontal, a short distance below the water-line. This guard prevents active heat from reaching the steam spheres, but at the same time sufficient heat reaches the upper angle of the boiler, to dry and partially superheat the steam ere it reaches the outlet to the steam-pipe at the upper cap. Priming is not usual in this boiler, with ordinary fresh water, and its peculiar construction causes it to be its own superheater, without separate apparatus. It is not essential that a stationary boiler should be set exactly as described, as the units may be built up vertically, horizontally, or in any irregular manner, best suited to the circumstances of the case. A stationary boiler set after the manner first indicated, and heretofore most generally adopted, has given very good and very economical results, when compared with other boilers having the best reputation. A boiler for marine purposes may be made in the form of a cube, and may be set without brick-work.

Having, as I think, in the previous pages of this volume, fairly proved that cast iron is to be preferred to wrought iron as a material for steam-boilers, let me say a few words in regard to the advantages of the former material as used in the "Harrison Boiler." Mr. Zerah Colburn, late editor of the London *Engineer*, and now editor of the new magazine published in London, called *Engineering*, has written much and very ably on the steam-boiler. His opinion, therefore, is entitled to great respect. In a paper on steam-boilers, read by him

before the Institution of Mechanical Engineers, at Birmingham, on May 5th, 1864, in alluding to mine, he says: "Although it cannot be said that cast iron is in itself a strong material for boilers, yet it will be seen that in the form now described, it affords greater absolute strength against bursting than is possessed by any form of plate iron boiler. The 'units' are cast upon green sand cores, so placed that they cannot alter their position in the flask by any force short of what would be sufficient to crush them to pieces; the thickness of metal in the spheres is therefore uniform throughout. In a 'unit' of four spheres, each sphere having an internal diameter of seven and a quarter inches, the whole area of the plane in which a bursting pressure could act, taken through the eight openings of the four spheres, is two hundred and twenty square inches, whilst the least section of iron resisting this pressure in the same plane is twenty-seven and a half square inches. The iron employed is an equal mixture of Glengarnock, Carnbroe and scrap. Its tensile strength may be safely taken at five and a half tons to the square inch. At this rate the bursting strength of the units would be one thousand five hundred and forty pounds, or nearly three quarters of a ton per square inch."

And again, Mr. Colburn, in a paper read before the British Association for the Advancement of Science, at Bath, in 1864, says: "In ordinary boiler-making the geometrical advantage of the hollow sphere cannot be turned to account. It cannot be produced economically in plate iron, nor if in plate iron, could it be advantageously employed in a steam-boiler. The hollow sphere has this property, to wit: with a given thickness of metal it has twice the strength of a hollow cylinder of the same diameter. This is upon the assumption (which is correct when the cylinder is of a length greater than its own diameter) that the ends of the cylinder offer no resistance to a bursting pressure exerted against its circumference. Under over-pressure, a closed cylinder would take the shape of a barrel, and if of homogeneous material and structure, it would burst at the middle of its length, in the direction of its circumference. The circumference of a sphere of a diameter of one, being 3·14159, the sum of the length of the two sides of a cylinder of the same diameter, and having a plane of rupture of the same area, is 1·5708, or exactly half as much."

And in the same paper, he says: "The tensile strength of cast iron varies between five tons and fifteen tons per square inch. Considered as a material for boilers, only the minimum strength should be regarded." "Cast iron boilers of eight feet in diameter, and of great length, were at one time made, but these were manifestly objection-

able. The spherical form of a moderate diameter is preferable, and whatever is the strength of a riveted wrought iron cylinder, that of a cast iron sphere of the same diameter and same thickness of metal, will be the same. Plate iron of a strength of eighteen tons per square inch is virtually weakened to ten tons by the loss in riveting, and as the hollow sphere is twice stronger than the hollow cylinder of the same diameter and thickness, the cast iron having no joints, becomes equal in this comparison to the wrought plates."

"If we could always count upon the maximum strength of iron, to wit: twenty-seven tons per square inch for wrought and fifteen tons for cast, a fourteen feet cast iron sphere would have the same strength to resist bursting as the seven feet cylinder of the Lancashire forty-horse boiler, supposing the same thickness of metal in each case." "But there is no occasion to make a boiler as a single large sphere, for it is now ascertained from extensive experience that hollow cast iron spheres of small diameter, do not retain the solid matter deposited by the water. Small water tubes, and indeed all small water spaces in ordinary boilers, always choke with deposit when the feed-water contains lime, but cast iron boiler spheres, although they may be temporarily coated internally with scale, are found to part with this whenever they are emptied of water. *This fact is the most striking discovery that has been made in boiler engineering.*" It removes the fatal defect of small subdivided water spaces, which can now be employed with the certainty of their remaining constantly clear of deposit. "This discovery has been made in the use of the cast iron boiler invented by Mr. Harrison, of Philadelphia, United States." "In Manchester, with feed-water taken from the Irwell, or from the canal, a hard scale is soon formed in the ordinary boilers; but in the cast iron boiler, a succession of thin scales of extreme hardness are found to form upon, and to become detached of, themselves from the inner surfaces of the water spheres. The scales are blown out with the water at the end of the week, and only small quantities can be found when purposely sought for. A pint of loose scales and dirt is the most that has yet been found in a careful internal examination, after nine months' daily work." "None of *the cast iron is removed with the scale.*" "The self-scaling action which has been found to be the same in all cases where the boiler has been worked, can only be explained by conjectures, which it is not, perhaps, necessary to introduce in the present paper. It deserves the careful investigation of the chemist and mechanical philosopher, with whom the author prefers to leave the subject."

The property of casting the scale, as stated by Mr. Colburn, was

not aimed at when the Harrison Boiler was designed, and such a result was entirely unexpected when it was first put in use. It is true, nevertheless, that after three months' trial of my first boiler, at Messrs. William Sellers & Co., in 1859, no scale or other deposit of any kind was found therein; all that may have been formed, having been removed by merely blowing out once a week. Still, this short experience seemed hardly sufficient to establish a rule. Fearing and anticipating the usual trouble from deposit, and having a form of boiler that admits of perfect access to all its interior surface from without, by withdrawing the bolts, one at a time, I devised and made a very perfect instrument for removing the scale with perfect certainty, by mechanical means. But in addition to what has been stated by Mr. Colburn, a continued experience, running through many successive years, in Philadelphia and elsewhere, has proved that, as a general rule, the Harrison Boiler *does* regularly shed its scale by blowing it out, under certain directions, once a week. In no case has it been found necessary to use the instrument designed for removing the scale. There are, I think, several reasons why this peculiar form of steam-generator should have this property of shedding its interior scale or deposit. In the first place, cast iron, as a material for steam-boilers, has not the same tendency towards continued oxidation as wrought iron. Rust on the inner surfaces of a boiler, when made of the latter material, combines with the deposit, causing it to harden and cling with great tenacity to the metal upon which it rests, making it much more difficult to remove than simple earthy or chemical deposit. I do not think that the hollow sphere, in itself, has any special quality for throwing off scale; still I think it will be seen that the hollow sphere, in connection with the curved neck, may have this quality in a great degree. If the form of the interior of one of the units of the Harrison Boiler is carefully examined, it will be found that none of its inside surface makes a complete arch or a continuous ring. A hollow sphere, without opening of any kind, would bind deposit to its inner surface, just as it is bound in a tube of equal diameter, and from which it is often so difficult to be removed. In every instance in the "units" of the Harrison Boiler, the curved neck comes in to break up the continuous ring, and removes the abutment of the arch. What follows, as far as interior deposit is concerned, would seem obvious. When the deposit is fixed upon the inner surface of the unit, both metal and deposit are about the same temperature, and consequently nearly in equilibrium. The boiler is blown out under full pressure at the end of each week, just after the fires are drawn,

leaving the walls of the furnace at, perhaps, red heat. At one hundred pounds pressure to the square inch, the temperature of the "units" would be over three hundred degrees. The excess of heat in the furnace walls might raise this temperature to four hundred degrees or more, thus slightly increasing the size of the unit in every part. It is well known that earthy or chemical matter will not expand equally with metal, and from this cause a disturbance, no doubt, takes place, soon after the boiler is emptied, between the metal and the inside coating of deposit, causing the latter, perhaps, to crack or loosen itself. The boiler is allowed to remain empty until quite cold, the units then returning to the size they possessed before heat was applied to them. The contraction of the casting to its lowest point, and the non-contraction of the deposit in an equal degree, still further, (it is fair to infer,) disturbs the integrity of the deposit, and not arching itself as in a tube, it is no doubt partially thrown off, and in due course of circulation, finds its way to the lower parts of the boiler. When the boiler is again filled with water and fired, the partially clinging fragments of scale still remaining on the inner surface of the units, would evidently soon be removed, as the boiler became active in generating steam. I have not been able to learn exactly what goes on inside the boiler, but this particular form evidently does, almost with certainty, shed its scale when in use, and treated as described.

I have endeavored to show why it possesses this singularly remarkable and most useful property. In but one instance, as far as has come to my knowledge, in the use of several hundred of these boilers, has any difficulty arisen with deposit. This case occurred in the vicinity of Philadelphia, where water, taken from a well, formed a peculiar deposit very rapidly, which did not remove itself with blowing out, and caused consequent difficulty in the use of the boiler. It was at length taken down and reconstructed, and the water thereafter taken from the regular city supply. Since the change in the water no trouble has arisen from interior deposit, and it is now giving great satisfaction.

CIRCULATION OF WATER.

It is believed that the steam-boiler under consideration has many advantages in its water circulation, or rather in the facility with which the steam is delivered into its proper place, after its generation. When set as is usual at an angle of about forty degrees, the currents of water, in each section, when generating steam, ascend along the line of spheres nearest the fire, and through the intersecting necks,

carrying with these currents, the accumulating steam as it is thrown off from the inner surface, and delivering it at the upper angle, or steam-room portion of the section. The descending water-currents, at and near the water-level, find their way downward along the upper ranges of spheres, and through their intersecting necks, reaching, at length, the lower angle of the sections, from which point the circulation is continued, and goes on as before.

It should be noted that each section of this generator, no matter how large the whole structure may be, has in itself a uniform, separate and thorough system of water and steam circulation. In fact, each section is a distinct boiler. This system of water circulation throughout all the parts of each section, always regularly kept up, has much to do with the removal of interior scale after it has become detached from the inner surface of the "units," and may be explained as follows:

In actively generating steam, the water and steam circulation must necessarily be very active at the hottest parts of the boiler. This keeps the loosened scale or deposit in suspension for a time. But when it reaches the lower portion of the section, where the circulation is least active, from the water not being highly charged with steam, the deposit has a tendency to remain at the bottom of the section, at or near the outlet, ready to be discharged at the first opening of the blow-off cock.

Much has been attempted in the matter of more perfect circulation of water in steam-boilers, and consequent disposal of the steam after its generation, even to the using of compulsory means for effecting this important object. From the peculiar uniformity of the parts, and the manner in which the sections are set, it is believed that this boiler has a more perfect system of water and steam circulation, than any that has preceded it.

FIRE CIRCULATION.

The boiler under consideration, it is believed, has several advantages in the application of heat thereto. Its peculiar form softens the lines of circulation for the heated products of combustion, leaving no abrupt turns or out-of-the-way corners, so often found in the more complicated boilers, and at the same time presenting a series of uniform channels, with their equally uniform surrounding surfaces for taking up the heat. Unlike the long and narrow tube of the tubular boiler, each channel of fire circulation in this, is in full connection with all the others, both vertically and laterally, causing a better blending

of the elements that support combustion, and thus maintaining it for a longer period than can be done in the long narrow tube.

It has been proved by repeated experiment that tube fire surface (say, in tubes of two inches external diameter and under,) has a greatly reduced value, after the first two or three feet from the fire, when compared with fire-box surface. In some carefully conducted experiments made under my notice several years ago, at St. Petersburgh, Russia, it was found, in boiling water in the open air, that copper tubes of two inches external diameter, and one-tenth of an inch thick, laid horizontally, were very nearly equal to fire-box surface in evaporating power, for a distance of two and a half feet from the fire. Beyond that distance their value fell off rapidly, and five feet, with a most intense fire, seemed to be the maximum of really valuable fire surface. Between the ninth and tenth foot, (the latter being the extreme length of the tubes,) water could not be raised in temperature to two hundred and twelve degrees, after hours of continuous firing.

These experiments, often repeated, and always with the same result, were made with a fire-box twenty inches diameter and twenty inches high, out of which proceeded, horizontally, four copper tubes of the dimensions above stated. Great care was taken to ascertain the exact evaporating value of each separate foot of tube surface in the direction of their lengths, as well as the value of fire-box surface.

Let us consider, for a moment, why so large a portion of the tube surface had so little value. Flame, or inflammable vapor, entering a tube of small diameter, may, at the moment of entrance, be in full combustion, and have a temperature nearly or quite equal to the source from whence it springs. Passing into a tube one and eight-tenths inches internal diameter, surrounded by boiling water, the metal in the tube would have a temperature, at the pressure of the atmosphere, of not much above two hundred and twelve degrees. The vapor coming in contact with this comparatively low temperature of the tube, would soon be reduced below the point of combustion, and from that moment, no matter what heat-giving properties it might still possess, they would be of no further effect, and to the end of the tube the vapor would give off heat only as heated air.

MAINTENANCE.

From the small size of the component parts, and the simple manner in which they are put together, it will be seen that injured parts of the Harrison Boiler can be renewed with great facility. A sphere may crack, or portions of the sections, nearest the fire, may, from

lowness of water, become overheated and spoiled. The taking out of a few bolts, and the removal of a small portion of brick-work in a stationary boiler, permits the displacement of the injured parts, without disturbing the uninjured portions of the structure; whilst replacement being equally convenient, an injured boiler by renewal, *and not by repairs*, properly speaking, (for no injured part is ever patched or mended,) is soon rendered as good as new.

A large proportion of the whole boiler need not require renewal. Parts taken out, and unfit for use, are in a most convenient form for remelting, and in this respect the old material has much greater value, compared with first cost, than the worn-out wrought iron boiler. The latter, from great size, and the difficulty and cost of getting into a more convenient shape for reworking, is often almost unsalable.

TRANSPORTATION.

The facility with which this boiler can be maintained, will explain why it is easy of transportation. Usually it is sent from the workshop in sections very convenient and safe to handle, each weighing about a ton. These sections can be put into place, if necessary, through an opening five feet long and one foot wide. If it is required to still further reduce the size and weight of the separate parts, a section may be taken to pieces, so that no portion need weigh more than eighty pounds. Thus a boiler, no matter what its ultimate size may be, can be carried, in detail, in a man's hand, and may be put through an opening one foot square. The handling, transporting and placing of the unwieldy wrought iron boiler, is always a source of great expense, —often of danger and delay. Many a boiler has been run much nearer the point of disaster than it would otherwise have been, had its removal and replacement been a matter of more easy accomplishment. Many a disastrous explosion has occurred, and many a valuable life has been lost, for no better reason.

EXTERNAL CLEANING.

It has been shown how this boiler is kept clean inside. In the economical use of a steam-boiler it is of much importance that the outside should also be kept clear from all deposit tending to hinder the absorption of heat. It is always difficult, and sometimes impossible, to keep the ordinary steam-boiler free from soot and other deposit on its fire surface, whether in flues, plain cylinders, or the other numerous forms in which it is made.

The fire passages of the Harrison Boiler, being uniform, and all in connection with one another, external cleaning becomes a very simple process. Through the small doors just above the furnace doors, easy access is had to the interior fire passages, and a small jet of steam blown in various directions through these small doors from a hose attached to the boiler, having a pipe and nozzle arranged for the purpose, will effectually remove all soot or other deposit, keeping the spheres as clean outside as when first made.

TENDENCY TO RUPTURE.

Steam at ordinary working pressure has but little tendency to rupture any of the parts of this boiler, and might almost be left out as an element of harm, from the fact already mentioned, that the calculated bursting point is very many times greater than the working pressure of an ordinary high pressure steam-engine. Neither has the steam pressure any great tendency to separate the joints, as the necks being but three and one-quarter inches in inside diameter, might be held together under a pressure of one hundred pounds per square inch, with a bolt no larger than would sustain a strain of about eight hundred and thirty pounds.

Allusion has been previously made to the evils that affect all boilers from irregular expansion when in use. It is equally necessary in the Harrison Boiler to guard against this influence. It may be well here to consider this most important feature more fully. The powerful and irresistible action of this force begins its work at the moment fire is first applied to a steam-boiler, and little by little, too surely impairs its strength. It is most difficult to control when the material is in such form as not to admit of compensation or allowance, when subjected to its injurious effects. In ordinary boilers made of wrought iron, it is practically impossible to arrange the parts so as to prevent irregular expansion, and consequent undue strain from this cause. As it has been shown that it is equally impossible to make and put such boilers together when new, without undue strain, we have here two most powerful influences at work, tending to rend the parts asunder, (entirely irrespective of steam-pressure,) the importance of which as elements of danger are seldom, if ever, taken into account. Take a plain cylinder, if you please, the most simple form into which wrought iron can be put to make a steam-boiler. Put a fire under such a boiler, expending its most intense heat upon a short portion of one-half of its lower diameter, at the end over the fire-grate, the products of combustion thereafter coursing along

the whole length of the remaining half diameter, until the outlet to the chimney is reached. Under these circumstances, the lower line must be very materially increased in length over the upper line, and the whole structure will be then subjected to a series of most complicated strains, the position and nature of which we can only conjecture, and consequently cannot provide against. Extra thickness of material will not always remedy, and might even aggravate, the evil.

In more complicated boilers, this terrible ordeal of fire is often yet further intensified. Make such boilers of cast iron or other brittle material,—putting them into shape, entirely free from strain, (if this were possible,) and when filled with water to the proper level, let them be fired in the same manner as if made of wrought iron. That such boilers would break in pieces ere long is not doubtful. Made of wrought iron, they might not break up at once, but their greater tenacity would give them no immunity from the harmful influences that had so soon destroyed their more brittle competitor, and which might, in the end, prove alike fatal to both. It is not a very hopeful view, when we consider that these undue strains are not lessened when the boiler becomes weakened by corrosion, or has its strength impaired by any other cause.

The Harrison Boiler in its manufacture and use, is not liable to serious injury from undue strain, or from irregular expansion. Cast iron expands less at the same temperature than wrought iron, and this difference might seem likely to interfere with the tightness of the joints. But when it is considered that the heat is first applied to the spheres, and thence through the water to the bolts, the latter must always have a less temperature than the spheres, which practically brings both nearly in equilibrium. A due proportion being maintained between the bolts and the spheres, no trouble need arise from irregular expansion when the boiler is not unfairly used.

DURABILITY.

In an experience of several years with this boiler, no evidence of serious gradual depreciation has ever shown itself in any of its parts. Corrosion affects it but slightly. Its self-cleaning properties usually prevents overheating consequent upon interior deposit.

Breaking of spheres happens so seldom as scarcely to need mention, amounting to only about one-fiftieth of one per cent. in an aggregate of one hundred and fifty thousand spheres put in use. In fact, except from overheating or "*burning*," arising from too low water or other cause, and consequent warping of the "units," which, of

course, destroys the accuracy of the joints, I have not found any decided marks of depreciation after long use. When compared with the wrought iron boiler, it would seem practically indestructible.

SECURITY FROM EXPLOSION.

By what has been adduced, it must be seen that the Harrison Boiler is safe from destructive explosion. It is not, however, maintained that it cannot be burst in some of its parts, or that it might not, under certain exceptional circumstances, do personal injury, consequent upon the sudden discharge of water or steam. But it *is maintained*, that under no circumstances can it "*rend and scatter large masses of material, liberating at the same time large volumes of highly charged water and steam.*" Spheres have cracked, (always singly,) but they are not broken into fragments, thus causing a sudden discharge of the contents of the boiler. Consequent leaking at the fractured part may, for the time being, and until renewal, prevent the use of the boiler. Instances have occurred where a cracked sphere has been left in its place for several days without inconvenience or stoppage.

On page 131 of the February number of this Journal, for 1867, will be found a report of the "Committee on Science and the Arts," of the Franklin Institute, giving a detailed account of certain most severe tests that the Harrison Boiler was put to, in the effort to destroy it by steam-pressure, and other means. The attempted destruction utterly failed. Attention is called to this report as exhibiting some very remarkable results. When it is considered that eight hundred and seventy-five pounds per square inch of steam-pressure failed to burst any of the spheres in one of the sections,—that under such severe test every joint becomes a safety-valve, and when it is rendered certain, that under all circumstances of fracture the general integrity of the whole structure can be surely maintained, (a point most positively insisted upon,) then but slight injury can arise, in any contingency.

CONCLUSION.

Considering the plan, material and mode of manufacture of the Harrison Boiler, let me now revert to the *axioms* laid down by me as guiding principles in making a steam-boiler, and see how far they have been carried out.

1st. The boiler under consideration *is theoretically and practically safe from all destructive explosion.*

2d. It is *constructed upon a system of uniform parts, few in num-*

ber, easily made, and easily put together or taken apart, and not of costly material.

3d. *Its strength is in no respect dependent upon any system of stays or braces, whereby the inefficiency or rupture of one of these braces or stays can cause greatly increased strain upon the others, thereby endangering the whole structure.*

4th. *Its parts are not of great weight or size, and may be easily transported, or put into or be taken out of place.*

5th. *It has a principle of renewal allowing the easy displacement and replacement or interchange of any and all of its parts, without impairing or disturbing the material or workmanship of portions not needing renewal.*

6th. *Whether of large or small size, it has uniformly such elements of strength as will always render it capable of sustaining many times greater pressure than need ever be demanded of it in practice, and its safety is not impaired by corrosion, or the many other harmful influences that so soon and so seriously affect the strength of ordinary boilers.*

7th. *Its parts are made and put together, so that in case of rupture, no general break up can occur. Its contents may be discharged, but no explosion or serious disturbance of any kind can take place, consequent upon such discharge.*

8th. *It is constructed so as to permit the easy and certain removal of deposit of all kinds, from every portion of its interior and exterior surface.*

It is assumed that the better "guiding principles" in the construction of a steam-boiler have been fairly carried out,—that all other matters are at least equal, and that the result *is* a safer if not a better one than any that has preceded it.

ITS PRACTICAL AND COMMERCIAL SUCCESS.

Until the spring of 1864 no effort was made to test the commercial merits of the Harrison Boiler by offering it for sale. In the early part of 1863 a boiler of fifty horse-power was put up experimentally at the establishment of Messrs. John Hetherington & Sons, Manchester, England, and subsequently a smaller one at the same place. Both of these boilers worked well and gave great satisfaction up to the middle of 1864. Orders were also received for several others, to be erected in the neighborhood of Manchester. Several hundred tons of this boiler, made in England, were imported into this country in 1864, and put into operation into Philadelphia and other places.

Since October, 1865, I have been manufacturing the boiler at my own foundry on Gray's Ferry Road, Philadelphia. There are now at work, in the United States, boilers on my plan, varying in size from five to three hundred horse-power, with an aggregate of twelve thousand horse-power, all put in operation within the last two years and a half. Most of these have been erected in Philadelphia. Others in various parts of the Union, from Michigan to Georgia, and from Massachusetts to Missouri. Some have gone to Canada, and others to South America, Liberia and New Zealand. I have now large orders for the Eastern, Western and Southern States, and for our own city, with a constantly increasing demand.

The Harrison Boiler has met with more favor at the hands of the public, than could have been expected, considering the novelty of its material and form, and the prejudice that so naturally attaches to any effort aiming at an almost entire overthrow of a long established system. Its peculiarities invite criticism, and it would not appear strange if even many of those best acquainted with the subject generally, should pass this by with little attention, thinking at a glance, that it was so much out of the beaten track, as to seem utterly impracticable.

Nothing in connection with the use of steam has been so much discussed as the manner of making the apparatus for its generation, and to have called out, for a century past, such an army of thinkers on a subject having in the abstract but a few simple elements, there must have been, and no doubt still is, some inherent defect in the plans heretofore and now used. The field is evidently not yet exhausted, if we consider that in the United States alone, forty-nine patents were issued in 1865, and fifty-eight in 1866, for steam-boiler improvements; the lowest number being nearly double that of any preceding year.

If, in these pages, I have added to the stock of information tending to make the use of steam less dangerous to life and property, I have attained something. If I have been instrumental in producing a steam-boiler, that will take its place permanently, as a means of rendering steam generating apparatus more safe from destructive explosion, I shall have attained something more. If in my effort to improve a much used and much abused object, manifestly demanding improvement, I have only succeeded in proving a fallacy—I shall still have my reward.

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From the London Engineering, No. 29.

THE STEEL RAIL QUESTION.

THERE are few questions which now possess the same importance to railway engineers and railway companies as that of the substitution of steel for iron rails. It involves not only the broader consideration of the durability of rails, but it embraces also nice questions of the relative strength of steel and iron, of their cost when new, and their value when worn out. On the occasion of the recent discussion of Mr. Price Williams' paper at the Institution of Civil Engineers, the engineering advisers to the railways of the United Kingdom and the colonies, dealt practically and commercially with these questions, and we cannot interpret the result of the discussion otherwise than as a verdict in favor of steel rails, although we are still wanting precise data upon which the extent of their superiority over iron may be definitely pronounced.

Mr. Williams, in dealing with the question of the life of a rail, endeavored to bring it as far as possible to that of its mechanical service, and he made the tons moved over a rail the standard of wear, rather than the number of years during which it might be in use. Two rails, of equally good quality might be worn out, the one in three years upon one line, and the other in twenty years upon another, the wear following the total weight and the speed of all the trains running over the rail. The former standard approaches precision where that of the surface in years does not; but even the tons of traffic borne does not form a precise standard, inasmuch as the wear is related—we will not say in what ratio—to the speed, and to the maximum weights upon a wheel, besides being closely related to the general condition in which the line is maintained, and to that of the rolling stock. Mr. Williams found, from the results of careful observation and record, that good iron rails bore from twelve to fifteen million tons of moderately fast traffic and thirty-eight million tons of slow traffic, while Bessemer rails had borne ninety-five million tons of slow traffic without being nearly worn out on even the single face. It seems to be a notion that rails on down gradients should not wear out as fast as those on up gradients, and thus the question of the pitch and direction of gradients might be considered to enter also into that of wear. But the vertical pressure of a train or a single wheel upon an inclined rail is the same whether the wheel be rolling up or down, and it is the vertical pressure taken in connection with the total force of motion acting upon the train—or the work stored up in it—that determines the question of wear; and the destructive forces are the same, although the engine force may not be the same, in moving a train down a gradient, along a level, or up a gradient, the speed being supposed the same in each case. By destructive forces we mean the conjoined effects of vertical pressure and advancing motion. The utilized bite of the engine wheels must be harder

in going up than in going down a gradient; but it is not certain that the longitudinal force exerted along the rail by what we call the adhesion of the engine produces any sensibly destructive effect at all. In other words, supposing no slipping, it is not certain that any more wear attends the working of a locomotive in the ordinary manner than would attend its motion if towed over the line at the same speed. The friction, or so-called adhesion, whereby locomotives are self-moving, is demonstrably simple static friction, and, so long as there is no slipping of the surfaces in contact, it is not clear that the rails are sensibly injured by the longitudinal thrust of the driving-wheels acting upon them. Mr. Williams has found that, with the same tonnage on ascending and descending gradients of the same pitch on the Great Northern line, the falling rails wear out much the sooner, no doubt because of the greater speed maintained upon them. Thus, on a descending gradient of one in two hundred, between Hatfield and London, the rails are worn out in three years with an average traffic of twelve million tons. On a rising gradient of the same pitch, not far from Peterborough, the same quality of rails last six years, and bears twenty-five million tons.

The questions of durability and of strength have been decided, and, we may say, without any qualification or deduction, in favor of the steel rail. There were ninety-five and a half million tons over the Chalk Farm rail, and the Bessemer rails at and near Crewe Station have borne, in one part of the line, fifty-two million tons, with a wear of only five-sixteenths of an inch, and in another eighteen and a half millions with but three thirty-seconds of an inch wear.

As to strength to bear heavy strains and sudden and severe blows, the steel rails are almost beyond comparison with iron rails. Supported upon five feet bearings, steel rails were found by Mr. Kirkaldy to bear in one case over eighty thousand pounds applied at the centre, and not one bore less than twenty-five tons, while the iron rails, tried in the same manner, bore from thirty-six thousand pounds to fifty thousand pounds only. Mr. George Berkley has tested steel rails on three feet seven and a half inch supports, to a central bending strain of sixty-four and a half tons, and he has found the tensile strength of the steel to be from forty-one and a half to forty-three and a half tons per square inch, according as the steel was from the web or the head of the rail.

As for resistance to impact, Mr. Berkley not long since tested some Bessemer axles, of nearly the same quality as steel rails, with some most extraordinary results. They were railway carriage axles, three and three-quarter inches diameter, seven feet two inches long, and were placed upon bearings three feet apart. A falling "tup" or ball, weighing fourteen hundred-weight and three quarters, or nearly three-quarters of a ton, was then allowed to drop upon them from heights, successively, of five feet, ten feet, fifteen feet, twenty feet and thirty-five feet. The first axle bore five of these blows, and was deflected twenty-five inches, but there was no appearance of fracture. The second, after two blows of ten feet and fifteen feet, was then nicked with

a cold chisel expressly to break it, the fall then employed being twenty-five feet. A third axle, struck with a fourteen hundred-weight ball, bore blows from a height of eleven feet six inches, seventeen feet and twenty-three feet six inches, and finally broke with a blow of thirty-six feet fall. A fourth was broken by two successive blows from a height of thirty feet each. A fifth bore five blows, the fall rising progressively to thirty feet, but the axle was not broken. A sixth bore blows successively, the fall being ten feet six inches, and was then nicked and broken with a fall of twenty-five feet.

But axles are not rails, and Messrs. M'Clean and Stileman made some trials of the breaking strength of seventy-three pound steel rails and eighty pound iron rails for the Furness and Midland Railway Company. The rails were keyed in chairs four feet apart, and a five hundred-weight tup or monkey was employed. A fall of four feet produced no set in the steel rail, a fall of ten feet gave one inch set, and a fall of twenty feet two and a quarter inches set only. The rail could not be broken with the means at hand. A second rail took a set of only one inch from a twenty feet fall of the same weight, and a set of one and a half inch from a further blow of twenty-six feet fall. This, too, could not be broken. The iron rails, nearly ten per cent. heavier, broke, the one with a six feet fall of the same weight, the other with an eight feet fall. The sets were but trifling, showing, apparently, brittleness of the iron.

The durability and strength of Bessemer rails being thus proved and conceded, the next questions are those of first cost, interest on cost, and the value of the old material when worn out. If the steel rail last twenty years, where the iron rails last three, then the railway company will lay out of the whole cost of the steel rails for twenty years, where with iron the first cost is not only less, but a considerable sum is recovered at the end of three years towards further renewal. Then, again, it becomes a question whether it is fair, after what has been seen, to compare iron and steel rails of equal weight, and whether compound interest or simple interest is to be considered. It seems reasonable to suppose that the full advantages of steel rails would be had with considerably less weight than is employed with iron. Mr. Hawkshaw has expressed the opinion that the time has arrived when the weights of rails to bear high speeds, should be increased, and that the weight of steel rails should not be less than seventy pounds or eighty pounds per yard; but this is not opposed to the proposition that steel rails of lighter section than that of iron rails may be employed without sensibly diminishing the greater comparative durability of the former. It will perhaps be more satisfactory, however, to count upon equal weights in both cases, leaving any incidental advantage thereby gained for steel as an additional benefit. Steel rails are made at prices of from £12 10*s*. to £16, and iron rails cost from £7 to £8; if guaranteed, as are those made for the Great Northern, £9 per ton. It is doubtful, however, whether really good steel rails can now be had for less than £15, while really good iron rails cost £8 to£8 5*s*. Mr. Schneider, of Barrow-in-Furness, has publicly stated,

however, that first-class Bessemer rails may probably be made to yield a fair profit at £13, and we may perhaps look to this as the future price of steel, under extended competition and for a considerable time to come. We cannot yet say how many iron rails a steel rail may be, with certainty, depended upon to wear out. But we believe that no competent engineer who has expressed himself upon this subject considers the ratio of durability as less than three to one. In such cases we cannot adopt any precise data, but the general result of the comparison of the first cost, compound interest, and cost of renewal is in favor of steel rails, when these are assumed to wear out each three iron rails. Mr. Johnson, of the Great Northern Railway, has made a careful calculation, the results of which are embodied in a table of much value, showing the cost, year by year, and the total cost for twenty years, of steel and iron rails, at from £12 to £15 per ton for the former and from £7 to £10 per ton for the latter, renewals being allowed for, and compound interest allowed at 5 per cent. on all money as spent. Even this does not show the full value of steel, in the increased safety of the line, and in the lessened disturbance of relaying, &c.; but the results do show that steel may be adopted with confidence, and especially upon all lines where the traffic is great, and the consequent wear of rails rapid. From what Mr. Johnson has said, we cannot doubt that the Great Northern line, which has a few thousand tons of steel rails now in use, will eventually be relaid with them throughout. The Crewe works are of a capacity to make three hundred tons of steel rails a week, and between fifty and a hundred miles of steel rails are already down on the London and North-Western line. Mr. Harrison of the North-Eastern, is using them in considerable quantities. Mr. Fox, of the Bristol and Exeter, has found them to be far more durable than iron rails. Mr. Fowler and Mr. Hawkshaw are using them in their practice; Messrs. M'Clean and Stileman have recommended their use; Mr. Berkley has abundantly shown their great strength; and altogether the judgment of the profession may be said to have been distinctly pronounced in their favor. When worn out, Bessemer steel makes valuable scrap, worth from £7 to £10 per ton. Mr. Schneider, of Barrow-in-Furness, and who, if any one, should know, has stated that the quality of Bessemer metal, as now made, admits of its being cut up, piled, reheated and welded with nearly the ease, cheapness and certainty of iron itself. He finds no difficulty in welding; and the value of worn steel rails may be accepted therefore as at least in the same proportion to their original cost as holds good in the case of iron rails.

From the London Engineering, No. 56.

THE SUPPORTING POWER OF PILES.

Mr. Wm. J. McAlpine, a well known and eminent American engineer, has furnished us with the following formula for ascertaining the safe load which piles will sustain, his experience being derived from a

number of experiments made during the construction of the dry dock at Brooklyn, U. S., between the years 1845 and 1849. The foundations upon which the docks were constructed, consisted of about five thousand piles of round timber, from six to twelve inches in diameter, and driven from twenty-five to thirty-five feet deep into the ground, by means of piling machines provided with rams of about one thousand four hundred pounds weight, falling through a height of forty-five feet, between guides bound with smooth iron straps. The material over the whole surface, and to the full depth into which the piles were driven, was homogeneous, consisting of a fine sharp sand, which offered a very uniform resistance. Mr. McAlpine found that a pile thirty feet long, six inches diameter at the smaller end, and twelve inches diameter at the larger end, sustained about one hundred and fifty tons after it had been driven home, until it ceased to move by a hammer of a ton weight falling through thirty feet, and that, generally, piles of whatever size, and driven home by any weight, possessed a supporting power, as shown in the accompanying formula. This power was ascertained by loading the pile to be tested with successive weights of about five tons each, and leaving these weights in position for not less than half an hour.

The piles, driven home by a ram of two thousand two hundred and forty pounds, falling through thirty feet, generally moved under a load of one hundred and twenty-five tons; their supporting power is therefore taken at one hundred tons.

Let W = weight of the trial hammer = 2240 pounds.
" W′ = weight of a hammer proposed to be used.
" F = fall of the trial hammer = 30 feet.
" F′ = fall of hammer proposed to be used.
" Y = sustaining power of the trial pile.
" Y′ = weight which the proposed pile will sustain.
" X = extreme weight in tons which the pile will sustain.

1. Then with the same weight of hammer as used in the trial pile and any other fall,

$$Y' = \frac{100\sqrt{F'}}{5{\cdot}48}$$

2. And with the same fall, and any other height of hammer,

$$X = \frac{X + 2Y'}{3};$$

or, substituting for X and Y′ their values as found above,

$$X = 12{\cdot}23 \times \sqrt{F} + \frac{W'\sqrt{F'}}{400}.$$

Thus, taking the particulars, as stated above, of weight and fall of hammer used in driving the pile experimented with during the construction of the Brooklyn dry dock, we have—

$$X = 12{\cdot}23 \times \sqrt{30} + \frac{2240\sqrt{30}}{400} = 100 \text{ tons.}$$

From the London Engineering, No. 52.

CHILLED WHEELS FOR RAILWAYS.

We find a long letter on the above subject by W. W. Evans, who has for about thirty years been engaged in railway construction in the United States and in South America. The writer speaks in the highest terms as to the efficiency, economy and durability of these wheels. Thus he says: "Having used all classes and kinds of wheels, I am able to judge of the merits and demerits of each kind, and I have now no hesitation in saying that the introduction of the cast iron disc-wheel (as made in America) on any railway line would effect a great economy. The general impression in England is, that the cast iron wheel is not safe at high speeds, and that the wrought iron wheel *is* safe. In answer to this, I would say, that the cast iron wheel is used often at high speed on the rough roads, and in the severe climate of the Northern States and in Canada, without any accidents happening from them. I will give a large reward to any one who will produce a record of a single accident having happened from the use of such wheels as I have used and now recommend. I have traveled many thousand miles by rail in the United States, often over very rough tracks, often at speeds over fifty miles an hour, often when the temperature was below zero, (Fahr.,) and I have never been in a train where there was a broken wheel, or have I ever seen a broken wheel in a carriage on one of our railways. In opposition to this, I would state that three winters since, I recollect seeing in the English papers accounts of several severe accidents happening in England, from broken wheels during some very severe cold weather, and that there were various comments on the causes of these accidents, all of which led me to believe at the time that the wrought iron wheel was not as safe as the cast iron. As to the life of the wheel, I would say, that the cast iron wheel will run over one hundred thousand miles; that many have run over one hundred and fifty thousand miles; that there were wheels in the International Exhibition of 1862 that had run on one of the Canadian railways one hundred and sixty thousand miles; that from an official report of the Erie Railway, now before me, I find that the lowest average life was thirty-four and three-quarter months, and as they estimate their carriage mileage at over four thousand miles a month, the run of these wheels was over one hundred and thirty-nine thousand miles. The English wrought iron wheel is undoubtedly a good and true wheel when first made; but, being of soft material, it wears rapidly, and has to be turned true in a lathe, (after running twenty-five thousand to thirty thousand miles,) at a cost about equal to recasting a cast iron wheel. A wrought iron wheel will stand two turnings and sometimes three. The 'tread' of the cast iron wheel being chilled, and being harder than the best tempered steel, wears very slowly. I would mention, that while in St. Petersburg, a few

weeks since, the manager of the Moscow Railway told me, that they had tried every class of wheels, and found none to stand the roughness of that road and the severity of that climate but the cast iron chilled disc-wheel; and yet on examining the wheels they had in use, made by themselves of Swedish iron, I found them very inferior to the wheels I now propose to introduce here. They also told me at St. Petersburg, that they had last winter tried twenty of the German steel wheels, and broke five of them during the winter.

"I would mention that the merits of the cast iron wheel, when compared with the wrought iron, are greater and more strikingly visible on railways running in mountainous countries where the curves are sharp and frequent, and where the gradients are steep, requiring the use of the brakes the whole length of the descending gradients. These wheels, if once introduced on the mountain roads of India, will never be abandoned. I say this on the strength of their having been adopted on every railway where they have been tried.

"I will not copy any portion of the mass of evidence which I have before me, in letters from resident engineers and managers of railways in the United States, in reference to the merits of the cast iron chilled wheel, but enclose to you a copy of a letter from Alexander M. Ross, who was the English engineer of the Grand Trunk Railway in Canada, knowing that such testimony is all that would be required by any man who will allow himself to investigate the truth of a subject. With such evidence, it will be hard for any one to doubt the merits of the cast iron wheel. * * * * * * Messrs. Anthony Gibbs & Sons, of London, who are the chief proprietors of the Lima railways of Peru, can also tell you about these wheels, as I have recently sent to their railways a new set of cast iron wheels to take the place of the wrought iron wheels now in use there on their old carriages. Their American carriages had cast iron wheels, which have been running since 1858. The cast iron wheels on the Arica and Tacno Railway, in Peru, have been running since 1855. I am told by Mr. John Higan, of 11 New Broad Street, that there has not been any new wheels sent to that road since I finished it in 1856, yet those wheels were not in any way equal to the best wheels now in use. Last week I had one of these cast iron wheels broken at the Bow Station of the North London Railway in the presence of some engineers. The sledges used were of twenty-eight pounds each. Three hundred and twenty blows (many of which were with two hammers) were struck before the stout smiths engaged in the work could break out a piece; as many more blows were struck before they broke the wheel to pieces, and then being unable to break the boss or centre, it was placed under a steam hammer of great power and destroyed."

This is very strong evidence, and must go far towards convincing those abroad of what we on this side of the Atlantic know so well.

Mechanics, Physics and Chemistry.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute, by L. W. Leeds, Esq.

LECTURE I.

Philadelphia is one of the healthiest cities in the United States, and, in proportion to the number of its inhabitants, few more healthy cities exist in the world.

This is not owing especially to its mere healthy situation, but should be attributed, in a great measure, to the accidental superiority of the ventilation of a large proportion of its dwelling-houses.

Notwithstanding this comparative excellence, the theory of ventilation is not so thoroughly understood, nor is the practice so perfect, even in this city, that no advantage can be gained by further knowledge upon this subject.

Far from it. From the very best information we can command, and with the most accurate statistics at our disposal, we are forced to the conclusion that about forty per cent. of all the deaths that are constantly occurring are due to the influence of foul air.

The Registrar of Records of New York gives nearly half the deaths in that city as resulting from this cause.

The deaths in this city for 1865, according to the report of the Board of Health, were seventeen thousand one hundred and sixty-nine; the average age of those who died was between twenty-three and twenty-four years. It ought to have been twice that, as shown by some districts in the city and also in the country, where the houses are so arranged that they frequently have good ventilation.

Taking the deaths caused by foul air at a very low estimate, say forty per cent. of the whole, (the per centage from that cause is not so great as in New York,) we have six thousand eight hundred and sixty-eight deaths in this city, caused alone by impure air, in one year.

It is estimated by physicians that there are from twenty-five to thirty days of sickness to every death occurring; there would therefore be something like two hundred thousand days of sickness annually as an effect of foul air.

We all know how very expensive sickness is, but few persons realize

the enormous aggregate expense of unnecessary sickness in a city like Philadelphia.*

This subject has awakened much interest in Europe of late years, and has led to the expenditure of immense sums of money, for the purpose of improving the sanitary condition of their cities.

Dr. Hutchinson estimated the loss to the city of London, growing out of preventable deaths and sickness, at twenty millions of dollars annually, and Mr. Mansfield estimates the loss from this cause to the United Kingdom at two hundred and fifty millions of dollars.

In the single State of Massachusetts, an estimate exhibits an annual loss at over sixty millions of dollars by the premature death of persons over fifteen years of age.

It is estimated that a few only of the principal items of expense incurred by preventable sickness in the city of New York amounts to over five millions of dollars annually.

And if it is thought that Philadelphia is exempt from such enormous unnecessary expense, just glance at the report of the Board of Health for last year and see how the deaths from disease of the lungs largely exceed those from any other disease.

Consumption is almost entirely the result of breathing impure air,—it is as preventable by the exclusive use of pure air as *mania potia* or drunkenness is by the exclusive use of pure water. And see, too, what slaughter among the innocents; over twenty-five per cent. of the whole deaths were under one year of age.

The infantile mortality is by many considered the most delicate sanitary test. But why does such an intelligent community as this so neglect its own interest?

They have listened to and satisfied the first imperative demands of nature—shelter from the elements and warmth,—and in doing this they have not brought into use that much higher order of intellect that can alone teach them how to supply, in connection with an agreeable warmth, an abundance of pure air in their otherwise air-tight houses.

I have been much interested in examining a large collection of tables of the analysis of air, which accompany a report to Congress, on "Warming and Ventilating the Capitol," prepared by Thomas U. Walter, Professor Henry and Dr. Wetherill. These tables were made by men of various nations, giving the results of their analysis of air

* I mean merely pecuniarily—in dollars and cents—the cost in physical pain and mental anxiety, of course, cannot be computed in dollars and cents.

taken from all manner of places, from great elevations on the mountains and in balloons, from the valleys, from the centre of the ocean, and from the middle of the continent; in cities and in the country, in winter and in summer, at night and in the day, and also the comparative analysis of the air *out of doors and in houses.* Believing that these would be of much interest and assistance to us in the investigation of the subject under consideration, I have had copies made of some of the most interesting.

These give the per centage of carbonic acid in the air as the test of the amount of impurities in it.

This is not an infallible test by any means—there are various other causes of deterioration. There is the exhaustion of the oxygen constantly occurring to support combustion and animal life; there are various other deleterious products of combustion and respiration besides carbonic acid. But, as carbonic acid is always found in certain known proportions in pure air, and is always formed in certain known quantities by respiration or combustion, it is considered by many to give a very fair indication of the condition of the atmosphere with reference to its influence on animal life or combustion.

I think one of the most valuable lessons to be learned by the study of these tables is the uniform purity of the external atmosphere all over the world, even in large cities.

This is strikingly illustrated in the case of the analysis of the air in the city of Manchester.

We have nothing in this country like that city, where two millions of tons of coal are burned annually, the smoke from which fills the air and stretches like a black cloud far into the country.

This added to the five hundred tons of carbonic acid thrown from the lungs of its animal life every day, are many times that amount, (some two thousand tons,) daily, pouring out from its forest of factory chimneys.

To this city were the labors of the "Health of Towns Commission" first directed, to see if they could not find in the air of its streets that mysterious influence that has caused such alarm throughout the civilized world, as the thoughtful and intelligent sanitarian sees one-half of all his fellow-citizens hurried to untimely graves.

They were dissappointed, and well might Dr. Smith exclaim, after the most thorough and careful investigations, "How insignificant are the works of art in contaminating that vast ocean of air that is constantly sweeping over the surface of the earth!" But do not be dis-

couraged: more recent investigations have discovered the whereabouts of this pestilential breath.

I have placed the table of Dr. Angus Smith's analysis of the air of Manchester at the head of the list, and have copied it complete, because it is the only table that I have examined of the analysis of the air of towns in Europe or North America, in which there occurs an amount of carbonic acid exceeding ten parts in ten thousand.

Here we see three such cases in the twenty-eight experiments, one ten, one twelve and one fifteen.

The average of the whole is also greater than in any other similar tables, being about seven and a half parts in ten thousand. This is certainly quite a perceptible contamination, pure air containing four or four and a half parts in ten thousand. Yet considerable as this appears in this view, the additional amount of carbonic acid is only the proportion that would be added to the air, if unchanged, of a room fifteen feet square and ten feet high, by a father, mother and three children, with a gas-light, in seven minutes.

And this, probably, is the highest average contamination that is produced by artificial means upon the air of any city in the world.

There are, of course, great natural causes which affect the air of whole countries, such as the decomposition of great masses of vegetable matter similar to that occurring on the low, flat lands along rivers, especially where they overflow their banks, like the Ohio and Mississippi. The best system of ventilation, as applicable to this kind of foul air, is to keep as far out of its reach as possible.

The other tables giving the analysis of the air of London, Paris, Madrid, Geneva, Bolton, England, at various elevations on the mountains, on the Atlantic Ocean, Washington City and various other places, are interesting only because they show so great a uniformity in the carbonic acid, seldom exceeding six parts to the ten thousand, and seldom under four.

But now let us look upon the other side of the room. Here we have tables giving the "carbonic acid in houses." Here we will find very different results. But the first is a green-house, in that there is no trace of carbonic acid in the evening and scarcely a trace in the morning. Plants, you know, absorb the carbonic acid, and give off oxygen, while animals absorb the oxygen and give off carbonic acid, thus keeping up the equilibrium in nature, as is so beautifully shown in the aquarium. Plants are generally supposed to give off carbonic acid at night, but it must be in very small quantities.

I consider them very conducive to health in a living-room, morally and physically.

But this want of carbonic acid does not last long.

The next is M. Dumas' lecture-room. At commencement of lecture 42·5, and at close of lecture 67 parts in ten thousand.

Now, I think we are on the right track for discovering that mysterious poison that has carried so many of our friends to their graves, even in the very prime of life.

Here we have dormitories, 52; do., 37; asylum, 17; school-room, 30; do., 56; Chamber of Deputies, 16; Opera Comique, parterre, 15; do., ceiling, 28; stable, 7; do., 14; hospital, Madrid, 30; do., do., 43; air of bed-room on rising in the morning, 48; the same after being ventilated two hours, 16; railroad car, 34; workshop, Munich, 19; full room, do., 22; lecture-room, 32; beer-saloon, 49; and, worst of all, is a well-filled school-room, 72 parts of carbonic acid in 10,000.

That, I think, is enough. Here we have the solution of the whole mystery.

It is not in the external atmosphere that we must look for the greatest impurities, but it is in our own houses that the blighting, withering curse of foul air is to be found. We are thus led to the conclusion that *our own breath is our greatest enemy.*

The "Health of Towns Commission," in their investigations, after examining various trades, where the employees were confined mostly in houses, and having left the scavengers to the last, expecting to find a rich harvest of mortality among them, were much surprised to find them more healthy than many very clean occupations, but which were conducted in houses instead of in the open air. I have not the statistics before me, but I should not be surprised to learn that that singular race of beings that live in the sewers of Paris were as healthy, if not even more so, than the operatives of some of those exquisitely beautiful, clean, air-tight factories of New England.

There was quite an account made a few years ago of the wonderful cures of consumption that had been performed by the patient being removed to the stable where he could be in close proximity to the cow, and I have no doubt many consumptive patients would find great benefit by such a course of treatment, not that there is any virtue in the smell of the cow, but that the air of the cow-stable would be nearer pure than that of their own chamber.

Many go or send their families to the country in summer to get fresh air. Some go to the sea-side, others to the mountains; but there en-

sues a greater change in a few minutes in a close bed-room by being occupied by a family than there is difference between the external air of any city and that of the country.

The reason why cities are so much more unhealthy than the country, is not because the air in the street is so much more impure, but because the houses are so built together that this vast ocean of air cannot get at and through them to purify them as it does in the houses in the country, and the reason why Philadelphia is so much more healthy than its neighbor, New York, is because the houses here are built more like those of the country, so that the air can sweep all around them, and sometimes through them.

I therefore believe, that a family living in the filthiest street in our city, if they were careful to have a constant current of air from that street, filthy as it was, passing through the house at all times, night and day, would be more healthy, other things being equal, than a family spending their winters in the finest house, if kept air-tight, in the healthiest location in the city and their summer in the country, especially if they were always careful to exclude the *night air* from their bed-rooms.

I say "night air;"—there is, unfortunately, an unnecessary prejudice against what is termed night air, which means, I suppose, fresh external air from the dark.

To show that this is not a new idea, I will read a few lines from the writings of a very accurate reasoner and an eminently practical mechanic and philosopher, one who I consider even now one of the very best authorities upon the subject of heating and ventilation. I mean the illustrious man after whom this Institute was named, Benjamin Franklin.

In his letter to Dr. Ingenhaus, physician to the Emperor, at Vienna, he says: * * * * "for some are as much afraid of fresh air as persons in the hydrophobia are of fresh water. I myself had formerly this prejudice,—this *aerophobia*, as I now account it,—and dreading the supposed dangerous effects of cool air, I considered it an enemy, and closed with extreme care every crevice in the rooms I inhabited. Experience has convinced me of my error. I now look upon fresh air as a friend: I even sleep with an open window. I am persuaded that no common air from without is so unwholesome as the air within a close room that has been often breathed and not changed. Moist air, too, which I formerly thought pernicious, gives me now no apprehensions; for considering that no dampness of air applied to the outside of my

skin can be equal to what is applied to and touches it within, my whole body being full of moisture, and finding I can lie two hours in a bath twice a week, covered with water, which certainly is much damper than any air can be, and this for years together, without catching cold, or being in any other manner disordered by it, I no longer dread mere moisture, either in air, or in sheets or shirts; and I find it of importance to the happiness of life, the being freed from vain terrors, especially of objects that we are every day exposed inevitably to meet with.

"You physicians have of late happily discovered, after a contrary opinion had prevailed some ages, that fresh and cool air does good to persons in the small-pox and other fevers. It is to be hoped, that in another century or two we may all find out that it is not bad even for people in health. And as to moist air, here I am at this present writing in a ship with above forty persons, who have had no other but moist air to breathe for six weeks past; everything we touch is damp, and nothing dries, yet we are all as healthy as we should be on the mountains of Switzerland, where inhabitants are not more so than those of Bermuda or St. Helena, islands on whose rocks the waves are dashed into millions of particles, which fill the air with damp, but produce no diseases, the moisture being pure, unmixed with the poisonous vapors arising from putrid marshes and stagnant pools, in which many insects die and corrupt the water. These places only, in my opinion, (which, however, I submit to yours,) afford unwholesome air; and that it is not the mere water contained in damp air, but the volatile particles of corrupted animal matter mixed with that water, which renders such air pernicious to those who breathe it; and I imagine it a cause of the same kind that renders the air in close rooms, where the perspirable matter is breathed over and over again by a number of assembled people, so hurtful to health.

"After being in such a situation many people find themselves affected by that *febricula*, which the English alone call a *cold*, and, perhaps, from that name, imagine they have caught the malady by *going out* of the room, when it was, in fact, by being in it."

Now, to show that his hopes have not yet been fully realized, although one century has nearly closed since he wrote what I have just read, and this unnecessary and unfortunate prejudice against night air still prevails extensively, I will read a few lines from the highest public medical authority in this city. It is the instructions of the Board of Health for the prevention of cholera for 1866:

ARTICLE—"VENTILATION."

"Your premises, particularly sleeping apartments and cellars, should be thoroughly ventilated. Ventilation is no less a purifier than water.

"It cleanses by oxidizing and drying. Keep your houses open and your windows hoisted during the day in good weather, and from ten o'clock until four in the afternoon, that they may have the full benefit of sunlight and free circulation of pure air. *During the remaining hours of the day, and through the night, keep the windows closed.* When the weather is cool or rainy, be sure to keep a fire in the house, in order to prevent dampness, or in sparsely settled neighborhoods, or in the suburbs of the city, have a fire in the house the entire season."

On page 9 we read: "Be careful to dress comfortably for the season, *avoid the night air* as much as possible, and when thus exposed, put on an extra garment and do not go into *the night air* when in a state of perspiration."

Thus, while recognizing the great value and importance of ventilation in a general way, they give the most definite instructions for thoroughly and most effectually preventing it, because it is at night, especially when we are asleep and *cannot move from the air, that the air ought to be moved from us.*

The frequent recommendations to avoid "night air" are simply recommendations to smother ourselves to death, because the foul, poisonous exhalations from our lungs cannot be removed from our chambers without being replaced by night air; there is no other fresh air at night but night air.

The recommendation to build a fire in the house on cool days, and in low marshy districts every day in the year, is an excellent one.

The recommendation to dress warmly and to avoid checking a perspiration suddenly, are valuable suggestions and too much attention cannot be paid to them.

But they are of equally great importance in reference to day air as to night air.

To shelter himself from the sudden change of temperature after sundown is an animal instinct, and a very necessary one, which is strongly implanted in man and beast alike.

The harm comes from the fact of so intelligent and intellectual a body as the Board of Health of Philadelphia encouraging the accomplishment of this very desirable object, by thwarting that great universal law of our Creator, the ceaseless agitation of the air by which

it purifies itself, (and by which perversion of nature's laws millions are already being killed unnecessarily every year,) instead of their encouraging its accomplishment in that much more healthy and rational way by adding more clothing or more fuel to the fire, and still continuing to breathe the pure air at night as well as in the day-time.

I have practised for many years sleeping with my windows open every night, summer and winter, allowing the unobstructed breeze to flow across my bed, to the great improvement of my health and strength.

There is no objection in a well ventilated room to having a fire if desired. A small room with a hot stove or open fire and the windows open, is much more wholesome than a large air-tight room freezing cold.

(To be continued.)

From the London Chemical News, No. 348.

(Continued from Vol. LII., page 229.)

SUPPOSED NATURE OF AIR PRIOR TO THE DISCOVERY OF OXYGEN.

By George F. Rodwell, F.C.S.

XV. John Mayow.—We have mentioned in the preceding paper that, from an early period in the history of physical thought, the scientific had admitted a relationship between the air and nitre, undefined, indeed, and unintelligible, yet too palpable to be denied. The flexity of this theory is proved by the fact that it was maintained by philosophers who differed in the generality of their views, and who were more wont to oppose each other than to agree even upon the most trivial point. In this instance they acknowledged the main fact, and only differed as to the precise nature of the relationship. Towards the middle of the seventeenth century the theory was established upon a firmer basis; it was inevitable, in a period when the physical sciences began to engage the serious attention of mankind, when scientific literature was on the increase and new instruments and modes of research were perpetually invented, while experimenters were arising on all sides, it was inevitable, we say, that the value of a theory which had endured for so long a time should be critically examined.

We have before mentioned that Robert Hooke was the first who threw much light upon the subject, by asserting as part of his theory of combustion* that there is "a substance inherent and mixed with the air which is like, if not the very same, with that which is fixed in saltpetre,"

* For an account of this theory see the tenth of these papers, *Chemical News* for February 17th, 1865.

and which is the "dissolvent" of combustible bodies. Unfortunately, the experiments upon which this theory was founded were never published, and we are thus left completely in the dark as to their nature and the extent to which we may rely upon them.

Hooke's theory of combustion was eagerly embraced by an Oxford student named John Mayow,* who in 1674 published a volume of essays,† in which he extended the theory, and detailed a number of very ingenious experiments in support of it.

Mayow commences his treatise by affirming that nitre consists of an alkaline salt united with an acid, which latter derives its active principle from the air. This principle produces combustion, and is the cause of acidity. Mayow calls it "*fire-air*," "*nitre-air*," and "*nitro-aërial spirit*," indiscriminately. It will perhaps be most convenient for us to speak of it throughout, as *nitre-air*. The atmosphere does not consist entirely of nitre-air, as is proved by the fact that when a candle is allowed to burn in a jar of air standing over water, a portion only of the air is consumed. Nitre-air is not itself combustible, but it causes combustible bodies to be consumed by producing a fermentation (*fermentatio*), for combustion is a very destructive kind of fermentation. Nitre contains no combustible matter, as may be proved by throwing a small quantity into a red-hot crucible, when it will be observed that ignition will not take place until some combustible body has been added. Nitre-air is condensed in large quantities in nitre. It is for this reason that combustible bodies mixed with it can burn in vacuo, or under water. But although the nitre-air is all contained in the acid of nitre, the latter cannot inflame combustible bodies when poured upon them, because the nitre-air particles are surrounded by particles of water. It is needless to remark here, that Mayow was unacquainted with the now familiar experiment of pouring turpentine into nitric acid.

Mayow attributes the increase of weight experienced by antimony during calcination, to the fixation of nitre-air, a supposition borne out by the fact that he procured a substance exactly resembling calx of antimony, by treating the metal with nitric acid, and evaporating. Vitriol of iron is produced from marcasite by nitre-air forming an acid with the sulphur of the mineral, which acid unites with the iron. Rust of iron is formed by the union of nitre-air with iron. Vitriol of iron is a perfect vitriol, while rust is an imperfect vitriol.

Nitre-air is present in all acids; sulphuric acid is produced by the union of nitre-air particles with sulphur; wines are changed into vinegar by the assimilation of nitre-air from the atmosphere. Nitre-air is

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* Born 1645, died 1679.

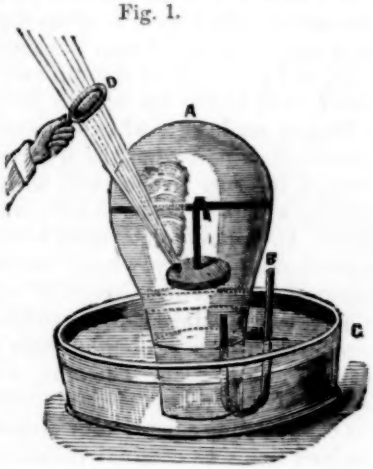
† This work is entitled "Tractatus quinque Medico-physici. Quorum primus agit de Sal-nitro et spiritu nitro-aëreo. Secundus de Respiratione. Tertius de Respiratione fœtus in utero et ovo. Quartus de Motu Musculari et spiritibus animalibus. Ultimus de Rachitide. Studio Joh. Mayow, LL.D. et Medici, nec non Coll. Omn. Anim. in Univ. Oxon. Socii.—Oxonii, 1674." The Vice-Chancellor's order for printing the work is dated July 17th, 1673. It was therefore completed in Mayow's twenty-ninth year. The first edition is very scarce, but the 1681 edition printed at the Hague, is comparatively common. The treatise on respiration was first published in 1668, in Mayow's twenty-third year.

also the cause of fermentation and of putrefaction; hence bodies covered with butter or oil, or otherwise kept out of contact with the atmosphere, do not putrefy.

Mayow treats at some length of the analogy between respiration and combustion, and we are here introduced to the first experiments in pneumatic chemistry.

A piece of camphor dipped in melted sulphur was supported in a glass jar, A, Fig. 1, standing over water. As stoppered air jars were not known at the time, (from the simple fact that they had hitherto been unneeded,) Mayow was obliged to adopt some special means for rendering the height of the water inside and outside the jar the same. He effected this by introducing a small siphon, B, which was placed in the position shown in the figure during the depression of the jar into the water vessel, C, and was afterwards withdrawn. The camphor was then fired by the lens, D. When it was extinguished, and the water had ceased to rise into the jar, he attempted to fire the remaining camphor, but without success.

Fig. 1.



In order to prove that air is diminished in volume by breathing, Mayow procured an open glass jar, A, Fig. 2, and tied firmly over the opening a piece of bladder, B, upon which he inverted a cupping-glass, C, containing a mouse. The edges of the cupping-glass were pressed firmly upon the bladder, so as to prevent communication with the outer air. It was soon observed that the bladder was pressed up into the cupping-glass, because, says Mayow, an inequality of pressure has been produced by the diminution of the bulk of air within the cupping-glass caused by the breathing of the mouse.

Fig. 2.

The experiment was modified by placing the mouse in a vessel inverted over water, when it was found that water rose into the vessel as the animal continued to breathe, and by roughly graduating the vessel Mayow calculated that the air was diminished one-fourteenth by breathing. He then attempted to ignite combustible matter in a closed vessel in which an animal had been suffocated, but without success, a proof that air which is unfit to support life is also unfit to support combustion. It was thus conclusively proved, that during the processes of respiration and combustion there

is a something abstracted from the air necessary for the maintenance of those processes, and that the residue is unfit to support either life or combustion.

A mouse was placed in a jar of air inverted over water, together with a lighted candle; the latter speedily went out, and the mouse lived only half the time that a mouse lived in the same bulk of air when the candle was not present; hence, argues Mayow, respiration and combustion both deprive the air of the same kind of matter, viz: of nitre-air.

Air deprived of its nitre-air particles is lighter than atmospheric air, because a mouse placed near the top of a closed vessel of air dies sooner than when it is placed near the bottom of the vessel; and if we take two mice, and place one at the top and the other at the bottom of a closed vessel, that at the top will die before the other.

Mayow made several experiments to determine whether air can be generated *de novo*, and the first artificially produced gas which he examined, in order to ascertain whether it was atmospheric air, was hydrogen, which, as we have seen, was procured some years previously by Boyle. In order to determine whether this gas was capable of as much expansion as air, Mayow made the following experiment: Hydrogen was procured by inverting a vessel of water over small pieces of iron placed in a vessel containing dilute sulphuric acid, and some of the gas was transferred* to a graduated tube in sufficient quantity to occupy the space of one division. The tube, with its lower end dipping beneath the surface of water, was then placed under an air-pump receiver, which was exhausted as completely as possible. The gas expanded to about two hundred times its original volume, and atmospheric air was not found to expand to a greater extent. It was thus ascertained that this property is common to both kinds of air; but the experiment proves nothing as to the nature of the generated air, because Mayow had previously found that air in which a candle had been extinguished was capable of expanding to a similar extent.

In order to ascertain whether air procured from iron filings and dilute sulphuric acid was respirable, Mayow placed a mouse in an inverted vessel partially filled with air, and noted the length of time before it died. The same volume of air was then passed into a similar vessel, a mouse introduced, and a large volume of hydrogen transferred to the vessel; but the mouse lived scarcely longer than its predecessor, whereas if the new air were respirable it ought to have lived two or three times longer. Mayow attributes the fact of its living rather longer to the dilution of the nitre-air particles by the introduced gas, and the consequent prevention of their rapid consumption.

We have seen that almost every writer on the nature of the air has touched upon the subject of respiration. In the first of these papers we have the theories of Plato and Aristotle: in almost the last that of Boyle. It was natural that a question so intimately connected with life

* The gas was transferred from one vessel to another by the method adopted in the present day, which, we believe, was devised by Mayow, since we have seen no mention of it in any work earlier than the treatise we are considering.

should from the earliest ages engage the attention of mankind. Indeed, almost the only evidence which the ancients possessed of the existence of air was derived from its necessity to animal life. From the continued observation that the cessation of breathing was the cessation of life, the belief became prevalent that the soul passed from the body with the last expiration of air; hence the expressions "*efflare animam*," "*exhalare animam*," "*expirare animam.*" Again, πνεῦμα, *spiritus*, and *anima*, have each the triple meaning of *soul*, *breath* and *wind*, and Mr. Hodges informs me that in Hebrew the word נפש means "*efflare animam;*" also that רוח has the three meanings of *soul*, *breath* and *wind*. The close connection existing between the function of respiration and the principle of life being thus clearly recognized and acknowledged, we cannot wonder that a number of theories were promulgated in every age to account for the precise nature of that function.

The more important of these theories were combated by Mayow in a treatise "On Respiration," which was far in advance of those of all previous writers on the subject. He had proved that only the nitre-air particles of the air are necessary for the support of life, and he contends that these particles are absorbed by the blood, whilst the rest of the air is rejected. The absorption of nitre-air produces heat in the body, and it is the object of respiration to produce animal heat, which arises from a kind of fermentation caused by the union of nitre-air with the combustible particles present in the blood. In like manner muscular motion is caused by nitre-air uniting with combustible particles in the structure of the muscle. During violent motion we breathe quickly, because nitre-air is required in greater quantity than when we are at rest, to supply the greater amount of muscular motion called into activity; and as combustible particles are removed very rapidly from the body under such circumstances, we require food containing a large quantity of such particles before and after violent action. When the chest is expanded, air, by its elastic force, rushes into the lungs, which are composed of a number of minute bladder-shaped membranes, through which nitre-air passes to the blood.

Mayow's work is remarkable in several respects. In it he conclusively proved that respiration and combustion are analogous processes. He upset the four-element theory by demonstrating the compound nature of air, and he recognized oxygen and nitrogen as clearly and almost as notably as they were recognized a hundred years later—the one the supporter of life and combustion, the principle of acidity, and the cause of fermentation and putrefaction, heavier than atmospheric air; the other incapable of supporting life or combustion, and lighter than atmospheric air. We find, moreover, in this work the dawn of the idea of chemical affinity, in the "fermentation" which he speaks of as taking place between nitre-air and combustible particles, and as tending to the production or destruction of things. Mayow even employs some of the terms in general use in the present day. Thus he speaks of "*affinatas*" existing between acids and earthy substances, and uses the words "*combinetur*" and "*combinentur*" in speaking of the "*congressus*" of different substances.

The treatise is characterized by much clear and condensed thought, well-sustained argument and accurate reasoning. Moreover, we seldom meet with instances of too hasty generalization, always the dominant source of error in the early development of a science. We further observe a great advance towards that exact and discriminative mode of thought which is necessary for the investigation of chemical phenomena. The period in which Mayow wrote was, as regards chemistry, a period of transition; there was as yet no work on scientific chemistry, yet Mayow's treatise approached more nearly to such a work than that of any of his predecessors. The works of previous writers in this direction belonged to one of the three following classes: They were either chemico-metallurgic, chemico-medical, or alchemical treatises, or they partook of the nature of all three. The publication of works on alchemy was fast waning before the advances of the new philosophy; for a superstition retreated, and as men began to devote their energies to the legitimate investigation of Nature, a false and chimerical art must of necessity cease to find votaries. Mayow was the first to discuss the intimate nature of an intangible body. Other writers had treated of the air as a whole, but no one had endeavored to ascertain the nature of its internal constitution, or to determine why it produces certain changes in surrounding bodies, upon what these changes depend, and the nature of the constituent or constituents of the air producing them. The old dogma of the elemental nature of the air was received as an absolute truth, although entirely unproven. It was thought that a theory which had been received since the earliest ages must of necessity be correct, and no attempt was made to disprove it.

We see from the above that it was the investigation of the nature of nitre which led to the knowledge of the constitution of the air. Mayow remarks at the commencement of his treatise, that so much had been written about nitre that it would appear "*ut sal hoc admirablile non minus in philosophia, quam bello, strepitus ederet; omniaque sonitu suo impleret.* "And, indeed, from the time of Mayow, nitre *has* made almost as much noise in philosophy as in war. If, on the one side, it has subdued unruly factions, has it not, on the other, destroyed obstinate theories? If it has dispersed turbulent assemblies, has it not dissociated the most firmly united compounds? New dynasties have arisen by its aid, alike in the realms of the earth and of philosophy. The greatest of the philosophic dynasties which has thus arisen was established by Mayow, and it has endured almost unchanged to the present day, a monument alike to his ingenuity, his perseverance and his scientific ardor.

(To be continued.)

(Continued from page 32.)

BALL AND SOCKET JOURNAL-BEARINGS.

By Coleman Sellers.

When journals are to be supported by bearing, attach to wooden frames, or to any frames which are likely to bend or twist, or when the

shaft between the journals, even in a rigid frame, is liable to be bent or sprung in working, there the proper bearing is one that can accomodate itself to the varying position of the shaft, and insure an uniform pressure over the whole surface, as, for example, in the line shafting for conveying and distributing power. Such lines are usually suspended from the girders or ceiling of the room, or attached by brackets to posts, &c., and are liable to be thrown out of line by the settling of the floors from loads, and other causes.

What is now known as the ball and socket hanger for this purpose, is a species of journal-bearing or box formed with a spherical surface in the centre of each half of the journal-bearing, so made that the centre of the sphere thus formed coincides with the axis of the journal and is equi-distant from each end of the box. This bearing is then held between concave surfaces, like a ball-joint, and while it is held central its ends are still free to vibrate a short distance in any direction, so that the journal in rotating in the box, controls the positions of the bearing so far as its general surface is concerned, but the bearing holds the journals in line. Hangers made with ball and socket-bearings of this kind are also provided with means of adjustment, so that settling of the buildings, &c., having thrown the shafting out of line, the bearings can be reclined without disturbing the attachment to the building.

In using cast iron for journal-bearings of this kind, it has been found that when the bearing is made four times as long as the diameter of the journal, a sufficient surface is obtained. This rule holds good up to say 4½ inches diameter of journal. For longer shafts it is customary to somewhat shorten the bearing, thus making 5 inch journal 18 inches long; 5½ inch and 6 inch, 20 inches long; 7 inch, 22 inches long and 8 inch 24 inches long.

The distance from centre to centre of the hangers, of line shafting, should be, if possible, uniform, and practice has shown that to use the least amount of material to do a given work, this distance should be for 1¾ inch and 2 inch shaft, 7 feet and not over 8 feet, and for larger sizes, up to 3½ or 4 inches, 8 feet and not over 9. The size of shaft to do a given amount of work, *i.e.*, receive and distribute a given amount of power, can be determined very conveniently by a table published at page 175, *Pocket-book of Mechanics*, by J. W. Nystrom. In this the number of revolutions of wrought iron shafts per minute being given in the top row of figuring, and the horse-power at the side column. The table shows size of shaft required for each case. Thus, for 50 horse-power, a shaft 5·38 inches diameter will be required, if the shaft makes only 40 revolutions per minute, but if it is to make 120

revolutions per minute, the proper sized shaft would be 3·73 inches. Now, this holds only for the first shaft, or that to which the power is applied from the engine, and in continuing the line and distributing the power, the shaft may gradually decrease in size, the rate of such decrease depending upon the nature of the work done at various points. As an example of the advantages of cast iron journal-bearing arranged in this manner, I may cite the case of a 24 inch circular saw, having its mandril journals fitted with solid cast iron ball and socket-bearings, *i.e*, with a box not made in halves, and therefore not capable of being closed up to compensate for wear, having been in daily use for over fifteen years and yet showing no appreciable wear.

(To be continued.)

EDUCATIONAL

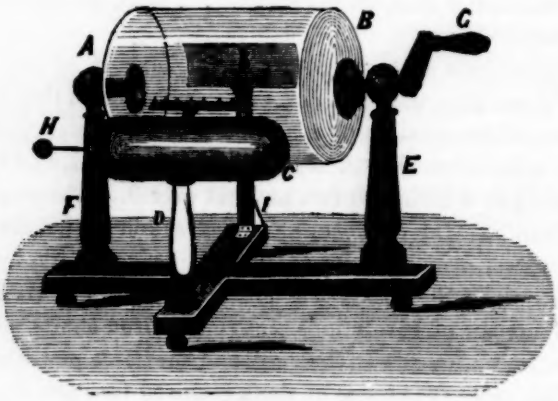
(Continued from page 54.)

LECTURES ON ELECTRICITY AND LIGHT.

Delivered before the Franklin Institute, by PROF. HENRY MORTON, PH.D.

HAVING acquired a general idea of the actions of the electric fluid in relation to the friction of dissimilar bodies, by the means already

Fig. 4.



described, we are in condition to understand the operation of those instruments by which these fluids are separated in a convenient man-

ner and in large quantities. Such instruments are known by the general names of Electrical Machines. The first and simplest of these is the Cylinder Machine. The form and structure of this apparatus is so familiar to all, that we will devote but a few words to its description, and then draw attention to a few points, of importance in securing from it the best effect, which are sometimes overlooked. A cylinder of glass, A B, which does not contain either lead or soda, is mounted on an axle of dry wood, or is supported by wooden caps, secured independently at either end. These caps are supported in journals, and to one a winch, G, is attached, with a handle for turning. A rubber of soft leather, R, is so placed as to press upon the cylinder as it rotates, and on the opposite side is arranged a large rounded conductor, H C, on an insulated support, D, and provided with a comb, or row of sharp metallic points, directed towards, and approaching closely to, the glass cylinder. It is hardly necessary to add that the electricities are separated by the friction of the glass and rubber, and that the positive fluid, going round with the glass, is taken off by the sharp points, and accumulated in the insulated body, which is called the prime conductor. To obtain the best effects from this machine, the rubber should be a good conductor, and in connection with the ground, so as to have an unlimited supply of positive fluid for the glass. If, therefore, the rubber is made of folded flannel, horse hair, or the like, covered with silk, strips of tinfoil should be inserted within it, and connected with the wooden upright which supports it. A silk flap or apron should also be attached to the upper edge of the rubber, and pass over the cylinder, reaching nearly to the collecting points on the other side. In this case, the cylinder is, of course, so turned that its upper surface moves from the rubber to the points. Upon the face of the rubber should be spread some electrical amalgam or some Mosaic gold, (bisulphide of tin.) The former is prepared by melting two parts of tin in a crucible, and to this, first adding three parts of zinc by degrees, and lastly, four parts of mercury, with constant stirring, then pouring into water to granulate. Or, one part of zinc, melted, and added to four parts of mercury in a mortar, and rubbed with the pestle until cold, is as efficient. Either should be pulverized in a mortar before use, and spread over the cushion, previously greased.

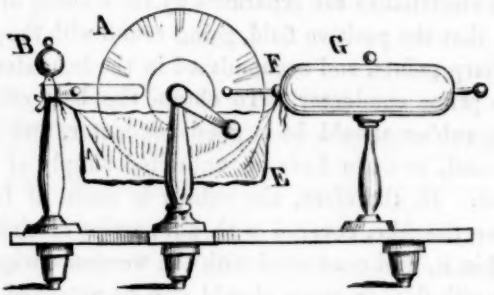
In place of either of the foregoing recipes, I have obtained an excellent effect with less trouble by dissolving scraps of tinfoil in a drop of mercury, until the mixture was semi-solid, and applying this with tallow, as before.

Mosaic gold is, however, decidedly preferable, on all accounts, as it can be applied without grease, does not scratch the glass and may be procured from those dealing in general chemicals, as it keeps without deteriorating.

The cushion or rubber is sometimes supported on a glass upright, for the purpose of obtaining negative electricity from it. (In this case the prime conductor should be connected with the ground.) But this arrangement is not to be recommended, as the cylinders are never perfectly true, and, in turning, produce an irregular strain, very likely to fracture the glass support. A wooden upright, hinged to the base and pressed against the cylinder by a stiff spring, I, is more reliable.

A more complete form of this instrument is that known as the "plate machine," represented in Fig. 5. In this case, a disk of plate glass, A, is supported by an axle on wooden uprights, and turned by

Fig. 5.



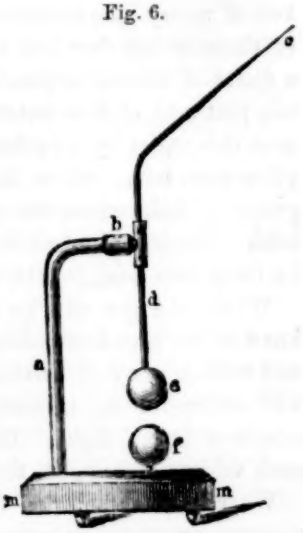
a handle. Rubbers are supported at B, on a glass upright, and are pressed by springs against the opposite surfaces, while prongs at F, passing around the plate, and provided with fine points on their inner sides, collect the positive fluid, and pass it into the prime conductor, G. The silk bag, E, prevents loss. In this, as in all like electrical apparatus, the parts intended to retain the fluids should be rounded; those to collect or to disperse it, sharp. The reason is obvious from a consideration of the fundamental properties already stated. "Particles of the same fluid repel each other." As a result of this, a sharp point connected with a charged conductor, affords a place from which particle after particle of the fluid may be easily pushed off, by the combined repulsion of the particles behind. Again, every transfer of electricity is a double action, as is indicated on page 54. When a positive spark passes from A to B, a negative one at the same instant goes from B to A. Thus, let A represent a positively charged body,

A | + + + + | and B a neutral one; then after a spark has passed

B | — + — + | from A to B, (as we generally express it,) the con-

dition of the two will be correctly indicated by A′ B′, A′ |—+++| in which we see not only that a positive particle has B′ |+++—+| gone from A′ to B′, but that a negative one has gone in the opposite direction, *i.e.*, from B′ to A′. Thus, the absorption of electricity by a point, becomes synonymous with the discharge of the opposite kind, and will follow the same rule. Hence, a point will not only give off electric fluid easily, but will also, as before stated, readily absorb it, the two actions being in fact identical, though we separate them in our idea. Thus, to give off positive, is to take on negative fluid, and to give off negative, is to take up positive in turn. There are various ways in which the above action might be explained, but that just stated seems to us the most direct. The *fact* of this process may be easily shown as follows: Such an apparatus as that represented at Fig. 6 is prepared. It consists of a wooden block, *m m*, to which are attached a brass ball, *f*, and a glass rod, *a*. The glass rod supports a bent wire, *d*, terminating below in a brass ball, *e*, and above in a point, *c*.

Fig. 6.



The point of the wire is directed towards some charged body, such as the prime conductor of the machine, Fig. 4 or 5, when sparks will be seen to pass between *e* and *f*, showing that fluid is being absorbed by the point. If the point is directed towards a positively charged body, such as the prime conductor already mentioned, we shall see upon it (if it is in a dark room) a star or point of light, such as will appear on a point connected with the insulated rubber of the plate machine, Fig. 5, and therefore indicating the *escape* of *negative* fluid; but if the point is turned upon such a negative body as the rubber above mentioned, it will show a rush of light such as would be obtained from a point on the prime conductor, thus indicating an *escape* of *positive* fluid. The sparks between *e* and *f* would, however, be the same in either case, for, as already explained, it would be a double discharge in both instances; positive going down, and negative up, in the first case, negative down, and positive up in the second.

(To be continued.)

(Continued from page 58.)

THE MAGIC LANTERN

AS A MEANS OF DEMONSTRATION.

We concluded in our last article, the subject of oxygen manufacture, and will now consider the best means of preparing the other essential material for the production of a powerful lime light, namely, hydrogen.

Preparation of Hydrogen.

The simplest method of preparing this gas in large quantity, as regards apparatus, is to provide a common glass gallon bottle, with a cork penetrated by a single bent tube; to place in this a pound or two of mossy zinc (obtained by pouring melted zinc from the height of three or four feet into a bucket of water); to pour over this about a quart of diluted sulphuric acid, previously mixed and cooled (about one pint acid to four water); to insert the tubulated cork, and connect this outlet by a rubber tube, with a wash-bottle and gas bag, or other reservoir. When the action in the bottle has ceased, if more gas is needed, remove the cork and pour in a fresh quantity of diluted acid. Three or four additions will develop gas enough to fill a thirty by forty inch bag, (=thirty to forty gallons.)

Where the gas can be conveniently stored in sufficient bulk, we know of no plan more economical, efficient and convenient, than this, and with a relay of bottles (which cost but a trifle), a few minutes will suffice for the manufacture of all the hydrogen needed for a couple of hours' light. But two volumes of hydrogen being used to each volume of oxygen, the reservoir must in this case be bulky.

Where these facilities for storing large volumes of gas are not present, an excellent arrangement is that figured in cuts 3 and 4. This, which is called a hydrogen generator, consists of a copper bucket, B C, about ten inches in diameter and two feet high, in which is placed a pail full of water and a quart of sulphuric acid. The copper bell, A, which fits loosely in the bucket, is provided with a movable perforated tray, which is introduced sideways, and when turned square across, is supported on lugs riveted to the lower edge of the bell. This bell is filled with fragments of scrap zinc. This

bell has also at its upper edge two lugs, I and H, which may rest on two iron rods, F E, attached to the bucket, as in the drawing, by which it is supported clear of the acid solution. A stop-cock, S, gives opening to a tube and small wash-bottle, D.

Fig. 3.

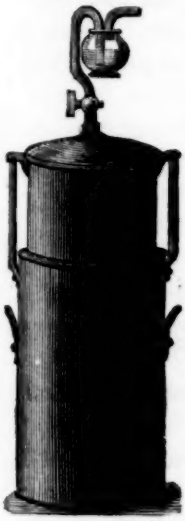
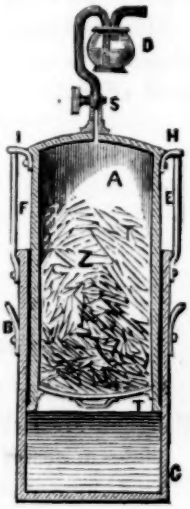


Fig. 4.



This stop-cock being opened, and the bell lifted from the supporting rods and lowered into the bucket, the zinc soon enters the acid, and hydrogen is liberated in large quantity. When the stop-cock is closed, the gas accumulates in the bell, expels the acid, which, rising in the annular space around, soon floats the bell so as to clear the zinc from the liquid when the action ceases. One or two small holes should be made in the bell, about half an inch from its lower edge; otherwise, on suddenly shutting off the escape of gas, enough may be generated by the liquid adhering to the zinc, to cause large bubbles to escape under the edge. These rising violently in the space between the bell and bucket, splash the acid about. The small holes, however, allow the gas to escape in minute bubbles, which do no harm.

The acid and water should be mixed beforehand, and allowed to cool. It requires some time to get the air rinsed out of the generator, so that the hydrogen may be ignited at the jet. After use, if the acid is not exhausted, and it is desired to employ the apparatus soon again, the bell may be supported as before; and if the level of the liquid is adjusted a little above that indicated in Fig. 4, the bell will remain full of hydrogen, and will not need any fresh "blowing out." If not to be used in a day or two, it is the best economy to throw out the liquid, or empty it into a stone-ware jar, even if not exhausted, as the copper is much corroded when it stands in the liquid and is not in use.

An apparatus such as described with the charge mentioned, will run a single lantern for over five hours, or a double (*i.e.*, dissolving) lantern for three hours. It is best to keep the bell pretty full of

scrap zinc, say twenty pounds, which will, of course, outlast many charges of acid and water.

In place of the wash-bottle attached to the bell, the same one used in the preparation of oxygen (page 58) may be employed, care being taken to blow out the oxygen left in it, before igniting the gas.

Messrs. Queen & Co. substitute for the wash-bottle, a sponge placed in a conical chamber immediately below the stop-cock, with good effect.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, February 20th, 1867.

THE meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that the Board had organized on the 9th of January, ult., by electing Messrs. Bloomfield H. Moore and Percival Roberts, Curators for the ensuing year, and appointing the following Standing Committees:

ON INSTRUCTION.

Henry Morton,
Wm. J. Horstmann,
Coleman Sellers,
Pliny E. Chase,
Robert E. Rogers.

ON ELECTIONS AND RESIGNATIONS.

O. Howard Wilson,
Henry G. Morris,
Henry Cartwright,
Samuel Wright,
Charles S. Close.

ON STOCKS AND FINANCES.

William Sellers,
Frederick Fraley,
James S. Whitney,
James Dougherty,
Washington Jones.

ON PUBLICATIONS.

Coleman Sellers,
Bloomfield H. Moore,
William B. Bement,
Samuel Sartain,
George Erety.

Donations to the Library were received from the Royal Geographical Society, and the Society of Arts, London, England; l'Ecole des Mines, la Société d'Encouragement pour l'Industrie Nationale, Paris; and la Société Industrie Nationale, Mulhouse, France;

K. K. Geologischen Reischenstalt, K. K. Geographischen Gesellschaft, Neiderösterreichischen Gewerbe-Vereines, Vienna, Austria; the Literary and Historical Society, Quebec, Canada; the Institute of Natural Science, Halifax, Nova Scotia; the Commissioner of Agriculture, Washington; the American Philosophical Society, H. P. M. Birkinbine, Esq., John Rice, Esq., and Doctor Edward Parrish, Philadelphia.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion, reported progress.

The Committee on General Totten's letter, with respect to the establishment of a Government Bureau of Examination and Experiment, reported progress.

The Committee to collect material relating to the history of the Institute, reported progress.

The report of the Resident Secretary was then read.

(The editor would here state that he proposes to publish the substance of the Secretary's Report in future, under other forms and in other parts of the *Journal*, as by this means new matters will receive earlier notice, and need not be delayed in publication, by any reference to the times of meeting.)

After the conclusion of the Secretary's Report, new business being in order, the following preamble and resolutions were offered by Mr. William Sellers, and adopted by the meeting:

PREAMBLE AND RESOLUTIONS ADOPTED AT THE MEETING OF THE FRANKLIN INSTITUTE, HELD FEBRUARY 20, 1867.

Whereas, In pursuance of the Act of Assembly, approved May 7th, 1864, a committee of the City Councils of Philadelphia is now engaged in the preparation of an ordinance for the regulation and inspection of the steam-boilers used within the city limits; and whereas, the objects contemplated by the act aforesaid and the proposed ordinance, cannot but have a very important bearing upon the manufacturing industry of the city; and whereas, the subject is one in which the engineering profession is particularly interested, and the committee having, by circular, invited suggestions as to the best method of accomplishing the object in view; therefore

Resolved, That the Secretary of the Institute be requested to procure fifty copies of the proposed ordinance for distribution among the members of the Institute, and that special meetings, for the consideration of the same, shall be held ever Wednesday evening, at 8 o'clock, until the provisions of the proposed ordinance shall have been fully discussed, and changes that may seem requisite shall have been recommended by the Institute for the consideration of the committee and of Councils.

Resolved, That notice of the proposed meetings, with the objects thereof, shall be given in three daily papers of this city, and that a copy of this preamble and resolutions shall be sent to each member of the Committee on Law, Select and Common Councils, with an invitation to attend the proposed meetings.

The following Standing Committees were then appointed by the President:

ON THE LIBRARY.

John C. Browne,
Robert Briggs,
Charles Bullock,
Pliny E. Chase,
Samuel Hart,
Bloomfield H. Moore,
Henry G. Morris,
Henry Morton,
Percival Roberts,
Samuel Sartain.

ON ARTS AND MANUFACTURES.

Wm. Adamson,
John H. Cooper,
Charles E. Foster,
C. Eugene Meyer,
Jacob Naylor,
Hector Orr,
Wm. G. Rhoads,
James B. Sword,
John C. Trautwine,
Samuel S. White,

ON MODELS.

James Agnew,
J. Sellers Bancroft,
William B. Bement,
Edward Browne,
Charles H. Cramp,
Mordecai W. Haines,
Addison Hutton,
John Kile,
W. B. Le Van,
John L. Perkins.

ON MEETINGS.

Henry Cartwright,
R. C. Cornelius,
Emile Geyelin,
Edward Longstreth,
H. G. Morris,
Henry Morton,
Robert E. Rogers,
Coleman Sellers,
Thomas Shaw,
E. Y. Townsend.

ON MINERALS.

Clarence S. Bement,
John C. Browne,
Isaac H. Conrad,
Emile Geyelin,
R. H. Lamborn,
Albert R. Leeds,
Theo. D. Rand,
Robert E. Rogers,
R. A. Tilghman,
Elias Wildman.

ON EXHIBITIONS.

John Agnew,
J. C. Cresson,
J. Gardiner, Jr.,
Frederick Graff,
Edwin Greble,
Wm. J. Horstmann,
W. A. Mitchell,
T. Morris Perot,
Coleman Sellers,
O. H. Wilson,

ON METEOROLOGY.

Samuel Allen,
Henry Bower,
Pliny E. Chase,
Charles M. Cresson,
Samuel J. Deal,
Jacob Ennis,
Caleb S. Hallowell,
James A. Kirkpatrick,
Benjamin V. Marsh,
Henry Morton.

ON SCIENTIFIC PROCEEDINGS.

Robert Briggs,
E. Geyelin,
Henry Morton,
R. E. Rogers,
Coleman Sellers.

Also, the President appointed as a Special Committee on the subject of Danger Signals—

Henry Morton, Thomas Shaw, John C. Cresson.

Mr. Samuel V. Merrick then announced the death of Professor Bache, which occurred on the 17th inst., and offered the following resolutions, which were unanimously adopted by the members, the vote being taken standing, in token of respect:

Resolved, That by the death of Professor Alexander Dallas Bache, the Franklin Institute has lost its most distinguished member, one to whose labors, while a resident of this city, it was indebted in an eminent degree, for the credit and reputation it obtained for its experiments on Water-power, on Steam Expansion, and on the Strength of Materials.

Resolved, That the Institute will ever cherish in grateful recollection, his services as an Officer and Manager, as Chairman of its Committee on Science, and his generous and warm sympathy with its members in every movement that would add to the progress of Science and the Mechanic Arts, and to the cultivation of liberal opinions and hearty social intercourse and good fellowship.

Resolved, That we sincerely mourn the loss that the family, friends and our whole country has sustained, in the decease of so good and great a man, and we tender our sincere and cordial sympathy and condolence, to all who are specially called on to mourn his loss.

Resolved, That a committee be appointed to attend his funeral, and to pay, on behalf of the Institute, the last tribute of earthly honor and respect to his remains.

Resolved, That Professor F. Rogers be appointed to prepare a necrological notice of Professor Bache, to be entered on the minutes of the Institute, and to be published in its *Journal*.

Resolved, That the President and Secretary be requested to forward a copy of these resolutions to the widow of Professor Bache, with a special letter of condolence and sympathy with her in her great bereavement.

Remarks on the above resolutions were made by Messrs. Fraley, J. C. Cresson, Robert E. Rogers and Robert Briggs, after which, all other business being suspended, as a mark of respect to the memory of Professor Bache, the meeting was, on motion, adjourned.

HENRY MORTON, *Secretary*.

Bibliographical Notice.

For the Journal of the Franklin Institute.

NOTES ON POLYTECHNIC SCHOOLS IN THE U. S.

By S. Edward Warren, C.E., Professor of Descriptive Geometry and Geometrical Drawing, Renss. Poly. Ins., Troy, N. Y. John Wiley, N. Y., Publisher.

Professor Warren, in his little pamphlet before us, has endeavored to give a concise and lucid description of polytechnic schools, with their "nature," "position," "aims" and "wants;" and, although we must take occasional exceptions to some of his remarks, it is in the main a most valuable addition to our educational literature, and we could wish it in the hands of all those who have the correct scientific training of our young men at heart. To properly appreciate the necessity of the popular mind being turned to this branch of education, we must reflect upon the past, present and future of this country. Great and marvelous as has been the growth of the United States during a comparatively brief period, it sinks into insignificance when we consider what the present rate of progression must necessarily bring about in the way of the future development of the arts and sciences.

While a younger people, with all the rich resources of a vast country lavished at our feet, it could not be expected that much attention would be given to an economical utilization of those resources. But now the rapid and almost incredible increase of our public improvements, those great civilizers of mankind, involving millions of dollars, demand that there shall be men specially educated for such works, not only in order that capital may be utilized to its fullest extent, but also that, by a proper care, the natural products of the country may be economized in every way. It has been within but a brief period that the educators of this country have realized these facts, and for many years the Rensselaer Institute (founded 1825 and remodeled in 1850) was the only institution in the land that pretended to prepare young men for the intelligent discharge of the duties of the engineer and technist. It was a start, however, and the Rensselaer Institute may be considered the pioneer of that class of schools whose especial object is the scientific and practical training of young men in the various departments of the arts and sciences.

Professor Warren begins by giving a list of such schools in the United States, with as brief explanatory notes as possible, so that a proper conception of their specialities may be had. The list, in the form of a table, gives the courses pursued at each institution, with the length of each course, the degrees conferred, and also the total attendance during 1865, with the age required for admission. From it we learn that there are eighteen such schools, all of which, with two

exceptions, are located in the Northern States. Of these two exceptions, one is not in operation and the other is imperfectly developed.

In treating of the educational in general, and the preparation necessary for a polytechnic training, Professor Warren, in a necessarily abstract way, endeavors to show that polytechnic schools are, in every sense of the word, professional, equal and, in some respects, superior in dignity to those schools that are popularly recognized as such. We are to view "science" in its "subjective" or "objective" relation to man. The former embodying what relates to his physical or spiritual constitution, the latter relating to all external nature upon which man is dependent for his comfort, happiness and well-being. It is the latter that lies at the root and is the foundation of all technical professions in their various ramifications, as well as the "material fine arts of architecture and music." Surely there is no nobler operation of the mind, than when turned to the study and utilization of the external universe, bending all things to minister to the crowning member of creation—man. There are three decisive tests, Professor Warren goes on to say, which determine the professional character of a school. * * "the *talent* demanded by them, the *extent* and *elevation* of their *courses* of *study*, or the *magnitude* and *beneficence* of their results, stand in two distinct groups, '*Humanistic*' or '*Polytechnic.*'" The former embodying such professions as the law, medicine, theology &c., and the latter, engineering, physics, chemistry, &c.; the one subjective science, the other objective.

We are glad to see, when speaking about the various modes of instruction, the author giving his experience as against the system of lecture instruction. Not that he desires to do away with the system entirely, but to restrict its use to those matters purely descriptive, "in which an error does not vitiate the whole," to "experimental subjects which address themselves largely to the senses," and to "mathematical subjects only in the case of proficient students." To this last exception, we must remind the author of a remark in the same paragraph, where he well and truly says, "that all knowledge of mathematical subjects must necessarily be exact or worthless." Now, we hold that this will apply to advanced or proficient students, as well as to those struggling along the outskirts of that dry and arid science. *All* mathematics require thought and study, of various degrees of intensity, and no step can be taken forward, before the last one made is firmly planted and free from all danger of backsliding. What thought, we ask, can a student, no matter how brilliant or how proficient, give to his professor lecturing upon a new demonstration. No man can think in such a science as rapidly as men ordinarily talk in a lecture, and by the time one has grasped a preliminary idea, his professor is three or four steps in advance, and he is vainly endeavoring to "catch up." With the best of text-books, explanitory matter is needed from the instructor, but the student has the main thought before him, knows all his forms to be correct, and derives that confidence that the certainty

of each step gives, which is requisite for a full comprehension of the matter in hand.

We must ever remember, that in mathematics, one thought or meaning lost, renders the rest worthless. It takes but one rotten egg to spoil a whole barrel of good ones.

The hampering of professors, too often practised through a false economy, or perhaps ignorance, by making them discharge the functions of the tutor, Professor Warren protests against, gently but firmly, a righteous protestation, we think. A relief from these duties gives the head of the department opportunity for original research, so necessary for a healthful growth, relieves the professor from feeling himself a mere machine-instructor, and gives him a zest and zeal which cannot but react similarly upon both the students and school.

The daily labor in a polytechnic school can hardly be judged of by the number of hours required in its service; for, as Professor Warren remarks, when we take into consideration the engineering field exercise, laboratory and drawing-room practice, the "activity is largely physical as well as highly pleasant and invigorating." So that when we reflect upon these things, the diversion of time recommended by our author, "eight hours for sleep, an hour and a half for dinner and an hour for each of the other two meals, including healthful repose, makes eleven and a half hours, leaving twelve and a half for work," (page 18,) reduces itself nearly to, but about, "six hours mental activity," which experience shows is not wearysome in the least, and *ought* not to be burdensome.

Passing over the first part of the third section of the pamphlet under review, which treats of the nomenclature of schools in general, and their adaptation to polytechnic schools in particular, the peculiar functions of the professor are treated of, as well as his relation to the student, and reciprocally the relation between student and professor, and the spirit that should actuate them.

A short paragraph or so is devoted to exposing the foolishness of styling one man professor of engineering,—in other words, professor of a whole science. As well call one man professor of "medicine," a science embracing pathology, anatomy, surgery, &c., &c., each one of which contains enough in its study for one man to devote a whole lifetime to—or call a man professor of the "law," as if a single individual could master that vast subject in all its ramifications, and in all its entirety.

The few remarks of the author upon the spirit of polytechnic schools, are sensible and natural, and he takes a broad and comprehensive view of the relation of students to such schools. Like the student of law, theology or medicine, the polytechnic student is differently situated from the college or university student. Here a young man has chosen his profession for life, success in which depends upon his ambition to excel, followed up by a hearty and zealous attention to all labors and the course of training necessary for an entrance into the practice of his profession. It is this spirit that permits a professional school to

lack the appearance of discipline and control, that must be exercised by the liberal educational colleges, the great majority of whose students have no special object in view in their studies, and no anxiety, except, perhaps, the "cramming" for an examination. Professor Warren thinks that secret societies cannot, from their exclusive nature, flourish in polytechnic institutions, where the course of instruction is such as to inculcate a spirit of united research. Nor is it desirable that they should do so, as the history of all colleges, where they have a deep root, shows; there they are a sad draw-back to the prosecution of study, and cultivate conviviality and sociality, pretty much to the exclusion of all else. In speaking of literary societies as such, the author thinks there is no room for them in the schools of which we are speaking, but he recommends, if the disposition of students is such as to aggregate themselves into organized bodies, their organizations should be strictly scientific in their nature, "provided, that every member of them is qualified to contribute something, and pledged to do it," in the shape of original research, solutions of problems and discussions of special cases, and contributions of industrial drawing. Another object that he mentions may be introduced into such a society, is, through its graduates and others, to make collections of valuable professional reports, and of valuable papers and pamphlets bearing upon educational matters relating to the profession. In this way, and in this way alone, Professor Warren thinks that societies may be useful adjuncts of a polytechnic school—in any other form he evidently views them as pernicious. In an abstract way we heartily agree with him; but taking the bull by the horns, we must own that it is impracticable, simply because the age and immature habits of study in the student prevents him from appreciating such a decidedly voluntary effort, involving much outside study, when he considers the time exacted from him by his professors sufficient employment. Nine men out of ten, no matter how faithful they are in the discharge of their school requirements, prefer to devote any outside time that may remain to them, in recreation. We have now arrived at a subject of great interest, and that is, the proper qualification for entrance to polytechnic schools.

Of course, it is desirable that applicants for matriculation should have a thorough, liberal education beforehand, just as it is considered necessary for young men who intend to study law, medicine or theology. Professor Warren has tabulated the proportion of graduates in a few of the most important technical schools, and it is gratifying to find that there is a yearly increase, although small, in the applicants for professional matriculation, holding college degrees. Taking one instance, at random, in the Rensselaer Polytechnic Institute, we find that in 1860 there were three of seventy-five, while in 1865 the ratio had risen to ten in one hundred and fifty-two. A higher standard should be insisted upon than that now existing, and although it would be impossible to bar all except collegiate graduates, still we would advocate a rigid matriculation examination in all departments of a thorough English education, and that no applicant should be passed

merely because a mathematical proficiency is shown. Many young men, with a natural gift for mathematics, are passed in some institutions, who have an utter disregard of their mother tongue, and although they perform their *professional* exercises well through the whole prescribed course, graduate with no more idea of grammar and spelling than when they entered. And this is no fault of the school; for, as before remarked, such schools cannot pretend to teach other than professional matter, having nothing to do with matters pertaining to a liberal education. This difficulty, Professor Warren feels, and calls attention to: "The great want of polytechnic schools, is a class of preceding institutions." Institutions where the scientific and fruitful French and German living languages and modern history are substituted "for ancient history, and the dead languages of still more dead gods, and their corrupt intrigues," these need not be independent institutions, but part and parcel of our colleges and universities, which still are wrapt in a musty precedent of antiquity. There is some hope for a change in this respect, for there is undoubtedly a ray of light struggling to scatter the accumulated dust of ages, dimly but surely, and we hope that before another decade passes by, that the trustees of our universities and colleges will have fully waked up, and realize that we are not living in years long since gone bye, when there was no other literature but that of Greece and Rome, but in an age teeming with intellectual thought and vigor, the products of which should form the principal part of a liberal education. There is a point not touched upon in the work before us, but of vast importance, and that is the peculiar qualifications which should be embraced in the head of such a school as a polytechnic institution.

A polytechnic school is eminently practical, or should be so, to realize its full meaning. All its theoretic and scientific training should have a practical bearing. The higher classes are, it is true, intended to be so, but how far do they succeed? A young man receives his diploma of civil or topographical engineer, or perhaps bachelor of science or doctor of philosophy, and we ask, how far is he qualified to enter upon the *active* practice of his profession? We admit that the maximum time allowed in this country for our technical schools is insufficient for the practice desirable, but is all the time so appropriated economized to the best result? Let us go back a little further, and see who constitute the faculty of such a school, whose avowed object is to fit men for practical life. They are men learned in the several specialities, so far as books can teach them, students variously gifted, but always students, who have never been themselves one day in the field or workshop, or on public works of any kind. All the book-learning in the world will not take the place of practical experience. To be sure, all professors are not required to have had this experience, nor is the matter which they teach capable of anything but book instruction,—for instance, the chair of descriptive geometry or geometrical drawing,—that of pure mathematics or rational mechanics. But what we do hold, and the point that we are desirous of

making, is, that he who holds the chair of *applied* mechanics, or geodesic or construction, should have graduated in the school of public works, as well as being learned in the theory and science of his profession. He then would know what the student actually needed, and could cater to his wants, economizing to the *best advantage* a time already too short. After a student has mastered the theory of his profession, it is the detail and every-day practice that he wants and must have. Of course, correct models are essential, and models too of what he probably will need in *his own country*, and there is no detail of construction too mean to be useful to him. Those institutions where models are used, have usually examples of the elegant European work, such as for years to come could not be applied in a new country. The problem in all the public works of this country is, to do the most effectual work with the least possible outlay, a view that ought always to be kept before the American polytechnic student, and a view too that marks a line of demarkation from the practice of the continental schools. How many professors, who teach, for instance, bridge-construction, could go upon the ground and superintend the construction of a bridge of the simplest character? They could calculate the strains and proportion, perhaps the parts, but have no more idea of the framing or fitting up than a school-boy. What our schools need, is to have at their *head* one who, besides his education and student preparation, has been connected with various public works, and become familiar with the facilities of the workshop and foundry, and essentially practical in his own experience. Such men can be gotten, if the proper means are employed to secure them, and, above all, a proper compensation offered. Then, and not till then, will our polytechnic schools take that rank as practical and scientific educators that their name implies. How many students would a medical college, or a law school have, if the professors of the various departments had found all their knowledge from books, and had neither attended a patient in the one case, or tried a cause in the other? Here we leave the subject for the present, and advise all who feel interested in the matter in hand to invest in Professor Warren's little pamphlet. In conclusion, we must thank the Professor for his valuable contribution to educational literature, and at the same time remind him of his *quasi* promise of a fuller treatise next time. B.

A COMPARISON *of some of the Meteorological Phenomena of* JANUARY, 1867, *with those of* JANUARY, 1866, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	January, 1867.	January, 1866.	January, for 16 years.
Thermometer—Highest—degree	42·00	52·00	65·00
" date	5th.	13th.	29th, '64.
Warmest day—mean	37·00	43·67	58·33
" " date	6th.	13th.	15th, '63.
Lowest—degree	9·00	—9·00	—9·00
" date	16th.	8th.	8th, '66.
Coldest day—mean	16·00	2·67	—1·00
" " date	30th.	8th.	9th, '56.
Mean daily oscillation	10·61	12·52	11·89
" " range	5·03	7·20	6·48
Means at 7 A. M.	23·29	27·47	27·48
" 2 P. M.	29·29	33·98	34·81
" 9 P. M.	26·23	29·53	30·72
" for the month	26·27	30·33	31·00
Barometer—Highest—inches	30·443	30·757	30·757
" date	30th.	8th.	8th, '66.
Greatest mean daily pressure	30·407	30·665	30·665
" " " date	30th.	8th.	8th, '66.
Lowest—inches	29·337	29·565	28·911
" date	21st.	13th.	23d, '53.
Least mean daily pressure	29·426	29·642	29·086
" " " date	10th.	13th.	23d, '53.
Mean daily range	0·225	0·181	0·216
Means at 7 A. M	29·918	29·999	29·957
" 2 P. M	29·883	29·960	29·916
" 9 P. M	29·919	29·991	29·946
" for the month	29·907	29·983	29·940
Force of Vapor—Greatest—inches	0·183	0·369	0·505
" date	21st.	20th.	11th, '58.
Least—inches	·042	·024	·023
" date	30th.	8th	22d, '57.
Means at 7 A. M	·099	·127	·131
" 2 P. M	·109	·131	·146
" 9 P. M	·101	·133	·142
" for the month	·103	·130	·140
Relative Humidity—Greatest—per cent	94·0	100·0	100·0
" date	20th.	15th.	Often.
Least—per cent	40·0	32·0	24·0
" date	5th.	4th.	25th, '60.
Means at 7 A. M.	76·3	78·3	79·5
" 2 P. M.	66·3	62·2	67·5
" 9 P. M.	68·7	77·0	75·9
" for the month	70·4	72·5	74·3
Clouds—Number of clear days*	12·	8·	9·1
" cloudy days	19·	23·	21·9
Means of sky covered at 7 A. M	52·9 per ct	69·7 per ct	62·2 per ct
" " " 2 P. M	60·0	56·8	62·4
" " " 9 P. M	42·9	56·4	48·5
" " for the month	51·9	61·0	57·7
Rain and melted snow—Amount—inches	1·925	2·885	3·156
No. of days on which rain or snow fell	8·	7·	10·5
Prevailing Winds—Times in 1000	N69° 9′ w·424	N61° 3′ w·310	N61° 52′ w·325

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIII.] APRIL, 1867. [No. 4.

EDITORIAL.

PNEUMATIC DESPATCH.

THE great length and crowded state of chief thoroughfares in many of our principal cities through which great quantities of merchandise in small packages as well as mail matter, are daily transported, is drawing public notice in no small degree to the plan which is now, and for some years has been, in successful operation between the terminus of the North-western Railway and one of the District Post Offices in London.

Under these circumstances, we think it desirable to give a detailed account of the above apparatus and its operation, the material for which is derived from an editorial article in the *Practical Mechanics' Journal* for June, 1863.

The general principle of the Pneumatic Despatch may be briefly explained as follows:

A small cast iron tunnel or tube, arched above, but nearly flat below, about two feet nine inches high, and having nearly the same width at its broadest part, provided with a pair of rails, runs from one station to the other. On these rails run four-wheeled wagons, of which Fig. 1 shows an end view and half cross-section. The general